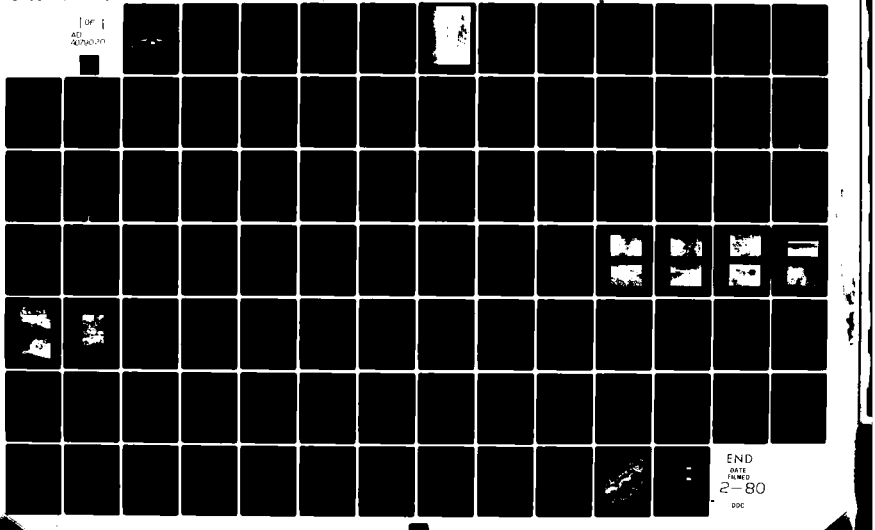
AD-A079 020 BAKER (MICHAEL) JR INC BEAVER PA F/G 13/13
NATIONAL DAM INSPECTION PROGRAM. GRAHAMVILLE RESERVOIR DAM (NDI--ETC(U)
AUG 79 DACW31-79-C-0011
UNCLASSIFIED NL



END
DATE FILMED
2-80
DDC

LAKE ERIE BASIN

SIXTEEN MILE CREEK, ERIE COUNTY

PENNSYLVANIA

GRAHAMVILLE RESERVOIR DAM

NDI No. PA 00020

PennDER No. 25-2

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

prepared for

DEPARTMENT OF THE ARMY

Baltimore District, Corps of Engineers

Baltimore, Maryland 21203

prepared by

MICHAEL BAKER, JR., INC.

Consulting Engineers

4301 Dutch Ridge Road

Beaver, Pennsylvania 15009

AUGUST 1979

Contract No. DACW31-79-C-0011

LAKE ERIE BASIN

GRAHAMVILLE RESERVOIR DAM
ERIE COUNTY, COMMONWEALTH OF PENNSYLVANIA
NDI No. PA 00020
PennDER No. 25-2

PHASE I INSPECTION REPORT.
NATIONAL DAM INSPECTION PROGRAM.

Grahamville Reservoir Dam (NDI PA-00020)
(PennDER 25-2) Lake Erie Basin
Sixteen Mile Creek, Erie County
Pennsylvania.

Prepared for: DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

Aug. 79 94

Prepared by: MICHAEL BAKER, JR., INC.
Consulting Engineers
4301 Dutch Ridge Road
Beaver, Pennsylvania 15009

DACW31-79-C-0011

PREFACE

This report was prepared under guidance contained in the "Recommended Guidelines for Safety Inspection of Dams," for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I Inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM

Grahamville Reservoir Dam, Erie County, Pennsylvania
NDI No. 00020, PennDER No. 25-2
Sixteen Mile Creek
Inspected 16 November 1978 and 5 June 1979

ASSESSMENT OF GENERAL CONDITIONS

Grahamville Reservoir Dam is classified as a 'Small' size-'Significant' hazard dam. The structure consists of a zoned, earthfill embankment approximately 29 feet high and 400 feet long.

Based on observations made during the visual inspection, data available from the Pennsylvania Department of Environmental Resources' (PennDER) files, and information obtained from interviewing North East Borough personnel and representatives from Hill and Hill Engineers, North East; the dam is considered to be in poor overall condition.

Hydraulic/hydrologic evaluations, performed in accordance with procedures established by the Baltimore District of the U.S. Army Corps of Engineers for Phase I Inspection Reports, revealed that the spillway will pass the 100-year flood without overtopping the dam. Therefore, the spillway is considered "adequate".

It is recommended that the owner initiate a feasibility study to determine if the reservoir is necessary for meeting the water requirements of the borough or whether the effort could be better spent upgrading one of its other reservoirs to meet the requirement for potable water.

If the study reveals the necessity for the continued use of the Grahamville Reservoir, the following recommendations should be undertaken by the owner without delay:

1) Engage the services of a qualified engineer to evaluate the seepage and its effects on the structural stability of the dam. The study should include recommendations for remedial action.

2) Begin clearing the trees and brush from the downstream slope, including 10 feet beyond the toe.

3) Place riprap or other protection on the upstream face.

4) Regrade and reseed the rutted areas, erosion ditches, and rodent holes.

5) Repair concrete on the gate valve house and repair the head wall for the 12 inch outlet pipes.

6) Clear the debris from the emergency spillway and diversion channels.

7) A plan for rapid closure of the upstream end of the pipes through the embankment should be developed and implemented in the event of a pipe rupture.

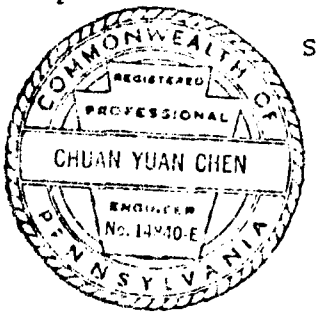
In addition, the following operational measures are recommended to be undertaken by the owner:

1) Develop a detailed emergency operation and warning system.

2) During periods of unusually heavy rain, provide around-the-clock surveillance of the dam.

3) When warning of a storm of major proportions is given by the National Weather Service, the owner should activate the emergency operation and warning system.

In the future, the owner should keep a record of the inspections and repair work done on the dam and concrete appurtenances.



Submitted by:

MICHAEL BAKER, JR., INC.

C. Y. Chen

C. Y. Chen, Ph.D., P.E.
Engineering Manager-Geotechnical

Date: 24 August 1979

Approved by:

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS

James Peck

JAMES W. PECK
Colonel, Corps of Engineers
District Engineer

Date: 12 Sep 79

GRAHAMVILLE RESERVOIR DAM

Overall View

TABLE OF CONTENTS

PLATES

APPENDICES

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
GRAHAMVILLE RESERVOIR DAM
NDI No. PA 00020, PennDER No. 25-2

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority - The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.

b. Purpose of Inspection - The purpose of the inspection is to determine if the dam constitutes a hazard to human life or property.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances - Grahamville Reservoir Dam is a zoned, earth embankment approximately 29 feet high and 400 feet long. The upstream slope is 3H:1V (Horizontal to Vertical); the downstream slope is 2H:1V and the crest is 16 feet wide. The principal outlet for the dam is two 12 inch cast-iron pipes which pass through the embankment at right angles to the axis of the dam, change direction in the gate vault, and discharge into the creek channel approximately 16 feet from the chamber. The pipe on the right has a 12 inch by 12 inch by 6 inch "Y" with the water supply line being connected to the smaller branch. All three branches are provided with valves below the junction.

A diversion channel, approximately 2550 feet long, is provided from the upstream right side of the reservoir, circling around the left end of the reservoir, and exiting below the dam into the downstream channel. The crest of the dike on the reservoir side of the channel is at approximately the same elevation as the main embankment.

The inflow to the dam is from two 18 inch cast-iron pipes that collect runoff from the drainage area to the left of the reservoir and from a 14 inch gravity line from the East Branch of Sixteen Mile Creek.

Upstream of the two 18 inch cast-iron pipes, a gate was placed to control the inflow to the reservoir; however, the gate is no longer in operating condition and is not used.

The emergency spillway, located along the left side approximately 175 feet upstream from the dam, includes three 8 inch cast-iron pipes. These pipes empty into a narrow channel which outlets into the diversion channel. The emergency spillway channel is 6 feet wide with 1H:1V side slopes on the left side and 1H:1V slopes on the right side to a height of 3 feet with a subsequent flattening to 10H:1V.

b. Location - Grahamville Reservoir Dam is located on Sixteen Mile Creek 3.75 miles southeast of North East Borough in North East Township, Erie County, Pennsylvania. The reservoir can be located on the USGS 7.5 minute quadrangle, North East, Pennsylvania at coordinates N 42° 11' - W 79° 47'. The location of Grahamville Reservoir Dam is shown on Plate 1.

c. Size Classification - The maximum height of the dam is 29 feet. The reservoir volume to the top of dam is 200 acre-feet. Therefore, the dam is in the "Small" size category.

d. Hazard Classification - Grahamville Dam is located several miles upstream from the Borough of Northeast. Since the stream valley downstream from the dam is relatively steep and narrow, some damages could occur as the result of an overtopping failure of the Grahamville Dam. Loss of life resulting from such an event, however, would be very improbable. The loss of water supply resulting from failure of the dam could be a significant economic loss to the Borough of Northeast. The dam is therefore considered to be in the "Significant" hazard category.

e. Ownership - The dam is owned by North East Borough, 58 East Main Street, North East, Pennsylvania 16428.

f. Purpose of Dam - Grahamville Reservoir is primarily used as an auxilary water supply for North East Borough.

g. Design and Construction History - The original structure was designed by Hill and Hill Engineers, North East, Pennsylvania and constructed by Simpson and Willis Contractors, Erie, Pennsylvania in 1906.

h. Normal Operational Procedures - The reservoir is typically maintained at a level corresponding to the amount of flow into the pond. The 6 inch water supply line is continuously left open at the dam and the water either feeds to or bypasses the water treatment plant, depending upon the control valve settings at the plant. Since the reservoir is not a primary source of potable water for the borough, the water bypasses the plant unless a severe shortage exists. The excess inflow passes through the emergency spillway and into the bypass canal.

1.3 PERTINENT DATA

a. Drainage Area (square miles) - 1.64

b. Discharge at Dam Site (c.f.s.) -

Spillway Capacity at Maximum Pool (El. 1242.6 ft.) -	230

c. Elevation (feet above Mean Sea Level [M.S.L.]) -

Average Top of Dam -	1243.1
Minimum Top of Dam -	1242.6
Normal Pool -	1237.3
Invert of Low Flow Pipes -	1237.3
Top of Roadway Across Spillway -	1238.5
Streambed at Centerline of Dam -	1214±
Maximum Tailwater -	Unknown

d. Reservoir (feet) -

Length of Pool at Top of Dam -	1300
Length of Normal Pool -	1300

e. Storage (acre-feet) -

At Normal Pool (El. 1237.28 ft.) -	140±
At Top of Dam (El. 1242.57 ft.) -	200±

f. Reservoir Surface (acres) -

At Normal Pool -	18±
At Maximum Pool -	22±

g. Dam -

Type -	Zoned earth embankment
Length (feet) -	400
Height (feet) -	29
Top Width (feet) -	16

Side Slopes - Upstream - 3H:1V
Downstream - 2H:1V
Zoning - The embankment contains two zones. The upstream and downstream slopes are constructed of clay and gravel with a center zone of clay only.
Impervious Core - Clay
Cut-off - Consists of clay puddle through the center of dam, 18 feet wide and 4 feet above original ground. The depth of the cut-off varies from 6 to 10 feet and was placed by cutting a trench in the shale foundation and filling it with clay puddle.

h. Dike -

Type - Zoned earthfill
Length (feet) - 2550
Height (feet) - 22
Top width (feet) - 10
Side Slopes - 3H:1V
Zoning - Consists of clay and gravel on both sides with a clay impervious zone in the center.
Impervious Core - Clay
Cut-off - Consists of a clay puddle approximately 14 feet high and 25 feet wide running the entire length of the dike.

i. Diversion and Regulating Tunnel - None

j. Spillway (Emergency) -

Type - Vegetated open channel spillway with three 8 inch cast-iron pipes for low flows
Invert Elevation of Low Flow Pipes (feet M.S.L.) - 1237.3
Elevation of Top of Roadway Across Spillway (feet M.S.L.) - 1238.5
Base Width (feet) - 6.0
Side Slopes - 1H:1V
Gates - None
Downstream Channel - The emergency spillway empties into the diversion channel.

k. Regulating Outlets - Consists of three valves, two 12 inch and one 6 inch, located in the gate vault on the downstream toe.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Pertinent design data were not available for the inspection report. Information that was available came from the Pennsylvania Department of Environmental Resources' (PennDER) files. The files contained the following information:

1) Dam inspection reports from the following years: 1915, 1916, 1917, 1920, and 1967.

2) Application dated 5 November 1923 for permission to raise the main embankment 8 feet. Further correspondence indicated that the project was abandoned.

3) Various correspondence dating from 1915 to 1936.

Along with the material contained in PennDER's files, information concerning the reservoir was obtained from interviewing North East Borough personnel and representatives of Hill and Hill Engineers, North East, the original design engineers.

Plates 3 and 4 were the only available drawings of the embankment. These drawings were submitted as part of the proposal for an addition to the embankment. Since the addition was never done, the crest elevation and normal pool elevation shown on the plans are not representative of actual conditions; however, since the drawings were submitted by the original design engineers, any other information is believed to be accurate.

2.2 CONSTRUCTION

The original dam was built in 1906 by Simpson and Willis, Contractors, Erie, Pennsylvania. Hill and Hill Engineers, North East, Pennsylvania, the designers of the dam, also provided full time inspection.

The dam, when first constructed, was only 25 feet high and had a storage capacity to the top of the dam of 160 acre-feet. An inspection and study of the embankment and reservoir area made by the Water Supply Commission, Harrisburg, Pennsylvania in January 1920 indicated that the diversion dike around the reservoir was too low and could be susceptible to overtopping, which would fill the reservoir and cause the dam to overtop also. In

1923, North East Borough applied for and received a permit to: 1) increase the height of the embankment 8 feet, 2) increase the height of the dike, and 3) construct an ogee spillway at the site of the present emergency spillway. Although the permit was received and the plans accepted, no work was done and the project was abandoned. However, some time during the late 1920's, the dike size was increased and the dam received an additional height of approximately 3.5 feet of fill. No documentation was available concerning this work in PennDER's file and therefore it is not known by whom the work was done.

In the early 1930's, a 14 inch line was installed as a gravity feed into the reservoir from the East Branch of Sixteen Mile Creek.

The only other changes made to the reservoir were the replacement of the flume across the diversion channel with two 18 inch cast-iron pipes and the placement of three 8 inch cast-iron pipes in the emergency spillway channel below the dirt road around the reservoir.

PennDER's files (formerly the Department of Forests and Waters) contain no correspondence between 1936 and 1967. This fact, along with information obtained from North East Borough personnel, indicates that the dam has received very little attention.

2.3 OPERATION

Operational procedures discussed in paragraphs 1.2.h., 4.2, and 4.3 were obtained from interviewing Mr. Herb Mallick, Borough Engineer for North East. No operation or pool level records are currently recorded by the borough personnel.

2.4 EVALUATION

a. Availability - The information reviewed consisted of PennDER's file on the dam along with information received from interviewing North East Borough personnel and the Hill and Hill Engineers' representative.

b. Adequacy - The information available is adequate for a Phase I Inspection.

c. Validity - There is no indication at the present time to doubt the validity of the available data.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General - The dam and its appurtenant structures were found to be in poor overall condition at the time of the inspection. The noteworthy deficiencies observed are described briefly in the following paragraphs. The complete visual inspection check list and field sketches are given in Appendix A.

b. Dam - Both the upstream and downstream faces of the embankment are covered with high grasses, bushes, and small trees. The upstream face has a 3 to 4 foot, near vertical drop-off at the normal pool elevation due to erosion of the embankment. Erosion was also noted approximately 200 feet from the right abutment on the downstream face. Some seepage was noted at the right abutment on the downstream side; however, due to the dense vegetative growth, an accurate assessment of the severity of the seepage could not be made, although no signs of piping were evident. Two large ruts have formed across the crest of the embankment due to vehicular traffic.

On 6 June 1979, a second inspection was made of the dam. At this time, the small trees and brush had been cut down. Although the debris had not been cleared, the inspectors were able to observe significant seepage (approximately 2 g.p.m.) at the toe of the embankment near the right abutment. Two rodent holes were observed on the downstream face approximately 75 feet from the left abutment.

c. Appurtenant Structures - The concrete is severely spalled and cracked on the outside of the control gate house located at the downstream toe of the embankment. The head wall for the two 12 inch outlet pipes has fallen over and the three 8 inch pipes at the auxiliary spillway channel are blocked with debris.

d. Reservoir Area - The reservoir area is a rolling, cultivated countryside. The greater percentage of land is used for growing fruit and the tops of the hills are mostly wooded.

e. Downstream Channel - Below the dam, the valley becomes a narrow gorge, the floor of which is shale, with well defined, steep side slopes covered with second growth timber and shrubs. A few miles beyond the mouth, the gorge gradually widens out, with the valley changing to rolling country covered with vineyards, fruit orchards, and berry patches. Approximately 2 miles below the dam, the stream is crossed by the tracks of the Conrail and the Norfolk and Western Railroads. The stream does not flow through the Borough of North East but passes around it on the west side in a semicircular channel.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

There are no formal emergency procedures in the event of impending catastrophe for the dam. According to North East Borough personnel, the dam is visited every day and the blow-off pipe is operated on a semiannual basis. No records of the visits or valve operations are kept.

It is recommended that a formal emergency procedure be prepared, prominently displayed, and furnished to all operating personnel.

4.2 MAINTENANCE OF DAM

The North East Borough Municipal Water Authority is responsible for maintenance of the dam.

4.3 MAINTENANCE OF OPERATING FACILITIES

The only operating facilities are the three gate valves located in the gate valve house on the downstream slope of the dam. These valves are operated twice a year by borough personnel.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

There is no warning system or procedure in the event of a dam failure. An emergency warning procedure should be developed.

4.5 EVALUATION OF OPERATIONAL ADEQUACY

The nature of Grahamville Reservoir Dam and its location are such that the dam is classified as a "Significant" hazard structure. The operational procedures appear to be adequate; however, a more conscientious maintenance program should be established. It is suggested that a system be established whereby all visits to the dam and maintenance items performed be documented. It is recommended that a plan for rapid closure of the upstream end of the pipes through the embankment be developed and implemented in the event of a pipe rupture.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data - Design plans and correspondence for Grahamville Dam were obtained from PennDER's files.

b. Experience Data - No rainfall or reservoir stage records are maintained for Grahamville Dam.

c. Visual Observations - A diversion channel and dike are located on the east and south sides of the reservoir which serve to divert most of the runoff from the watershed to the stream channel downstream from the dam. Some vegetation and debris are located in this channel which could cause an obstruction to flood discharges leading to overtopping of the dike. The spillway channel is also heavily vegetated. All vegetation and debris should be periodically removed from the spillway and diversion channels.

d. Overtopping Potential - Grahamville Dam is classified as a "Significant" hazard - "Small" size dam requiring evaluation for a spillway design flood (SDF) in the range of the 100-year flood to the 1/2 Probable Maximum Flood (1/2 PMF). Since the dam and reservoir are on the low end of the small size category, the 100-year flood was chosen as the appropriate SDF. The peak discharge for the 100-year flood was calculated in accordance with procedures outlined in the Soil Conservation Service Technical Release No. 55. The maximum discharge from the 1.64 square mile drainage basin, according to this analysis, is 580 c.f.s. The diversion channel was then analyzed to determine its ability to adequately convey the 100-year flood flows around the reservoir and dam. This analysis indicated that the upper end of the dike could experience minor overtopping of approximately 25 c.f.s. which would be discharged into the reservoir. Since this overtopping of the dike would be of relatively short duration and would produce flows of low velocity, it is not considered to be so serious as to cause any substantial damage or failure of the dike. In addition, approximately 40 c.f.s. could enter the reservoir through the three inlet pipes. This total inflow to the reservoir of 65 c.f.s. is, however, well below the spillway capacity of 230 c.f.s.

Ratios of the Probable Maximum Flood (PMF) hydrograph were also developed and routed through the reservoir with the aid of the U.S. Army Corps of Engineers' Flood Hydrograph Package, HEC-1. The inflow hydrographs, used in the analysis, were reduced by an appropriate amount to account for discharges routed around the reservoir by the diversion channel. The results indicate that the spillway and reservoir are capable of passing approximately 15 percent of the PMF without overtopping the dam.

e. Spillway Adequacy - The spillway diversion channel, as outlined in the above analysis, is capable of passing the 100-year flood which is approximately 10 percent of the PMF with no overtopping of the dam. Therefore, the spillway is "adequate" according to the recommended criteria.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations - Due to the existence of several seepage areas on the downstream side of the dam, it is almost impossible to accurately assess the structural integrity of the dam. Although piping conditions were not visibly evident during either inspection, the hydraulic gradient present at the seepage location indicates that piping could occur. As recommended in Section 7, North East Borough should seek engineering assistance in performing a more detailed investigation of the seepage and its effects on the structural stability of the dam.

b. Design and Construction Data - No design or construction data were available for this Phase I Inspection.

c. Operating Records - No operating records were available for Grahamville Reservoir Dam. Operational procedures obtained from interviewing the borough engineer do not indicate cause for concern relative to the structural stability of the dam.

d. Post-Construction Changes - It is not believed that any of the post-construction changes have had any adverse effects on the dam.

e. Seismic Stability - The dam is located in Zone 2 of the "Seismic Zone Map of the Contiguous United States," Figure 1, page D-30, "Recommended Guidelines for Safety Inspection of Dams." Since this is a zone of moderate seismic activity, no further investigation as to the seismic stability is necessary if the dam can be shown to meet the requirements of static stability. As stated in paragraph 6.1.a., the existence of a significant amount of seepage could have adverse affects on both the static and seismic stability of the dam. However, there will be no need for further considerations for seismic stability if the recommended engineering investigation shows the dam (with remedial measures, as necessary) has adequate structural stability.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety - The dam and its appurtenant structures were found to be in poor overall condition at the time of inspection. Grahamville Reservoir Dam is evaluated as being a "Significant" hazard - "Small" size dam in accordance with the "Recommended Guidelines for Safety Inspection of Dams" and should have a spillway capacity equal to the 100-year flood. As presented in Section 5, the spillway and reservoir were determined to have a capacity greater than the 100-year flood and are therefore assessed as being "adequate."

b. Adequacy of Information - The information available and the observations made during the field inspections are considered adequate for this Phase I Inspection.

c. Urgency - The owner should initiate the action discussed in paragraph 7.2 without delay.

d. Necessity for Additional Data/Evaluation - As discussed in Section 6.1 and paragraph 7.2, an investigation of the seepage and its effects on the structural stability should be initiated by the owner.

7.2 RECOMMENDATIONS/REMEDIAL MEASURES

It is recommended that the owner initiate a feasibility study as to whether or not Grahamville Reservoir is necessary for the water supply of North East Borough. The time and money that will be exhausted in performing the following recommendations and remedial measures may not be justifiable in terms of the potable water used from the reservoir. If the owner decides not to repair the structure, the reservoir should be drawn-down and the embankment breached. However, if the owner feels that the reservoir is an integral part of the water supply system of the borough and should remain intact, the following items should be performed by the owner without delay:

1) Engage the services of a qualified engineer to assess the seepage problems and their long-term effects on the structural stability of the dam. The study should include recommendations for remedial action.

2) The downstream slope, including 10 feet beyond the toe, should be cleared to facilitate future inspections.

3) Place riprap or other types of erosion control on the upstream slope to prevent erosion.

4) Regrade and reseed the large ruts along the crest with an appropriate mixture to prevent erosion.

5) Repair the concrete on the outside of the gate valve house. Also, repair the head wall for the two 12 inch outlet pipes.

6) Fill and reseed the rodent holes along the downstream slope.

7) Remove all debris and excess vegetation from the emergency spillway and diversion channels.

8) A plan for rapid closure of the upstream end of the pipes through the embankment should be developed and implemented in the event of a pipe rupture.

In addition, the following operational measures are recommended to be undertaken by the owner:

1) Develop a detailed emergency operation and warning system.

2) During periods of unusually heavy rain, provide around-the-clock surveillance of the dam.

3) When warning of a storm of major proportions is given by the National Weather Service, the owner should activate the emergency operation and warning system.

In the future, the owner should keep a record of the inspections and repair work done on the dam and concrete appurtenances.

PLATES

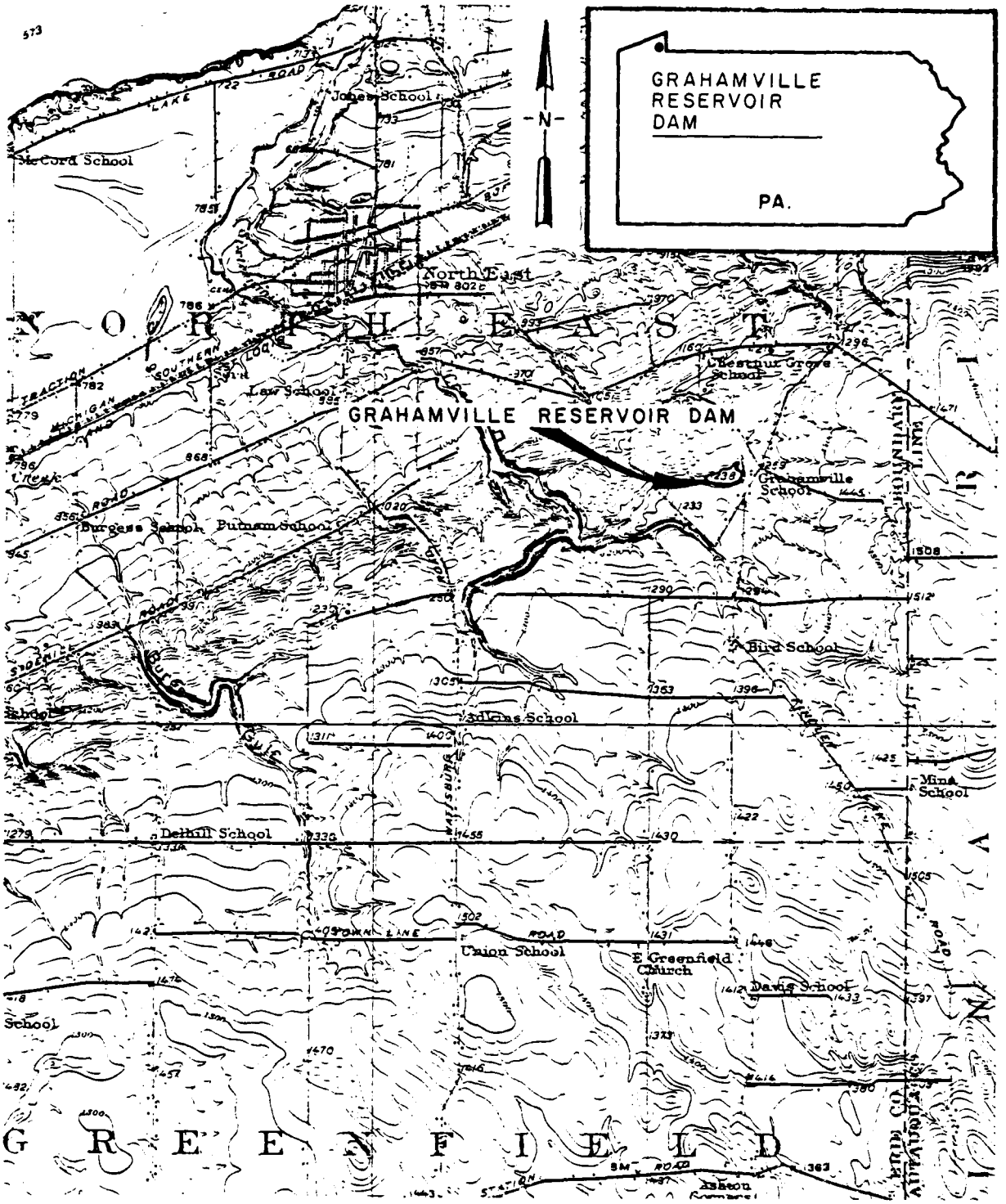


PLATE I LOCATION PLAN

GRAHAMVILLE RESERVOIR DAM

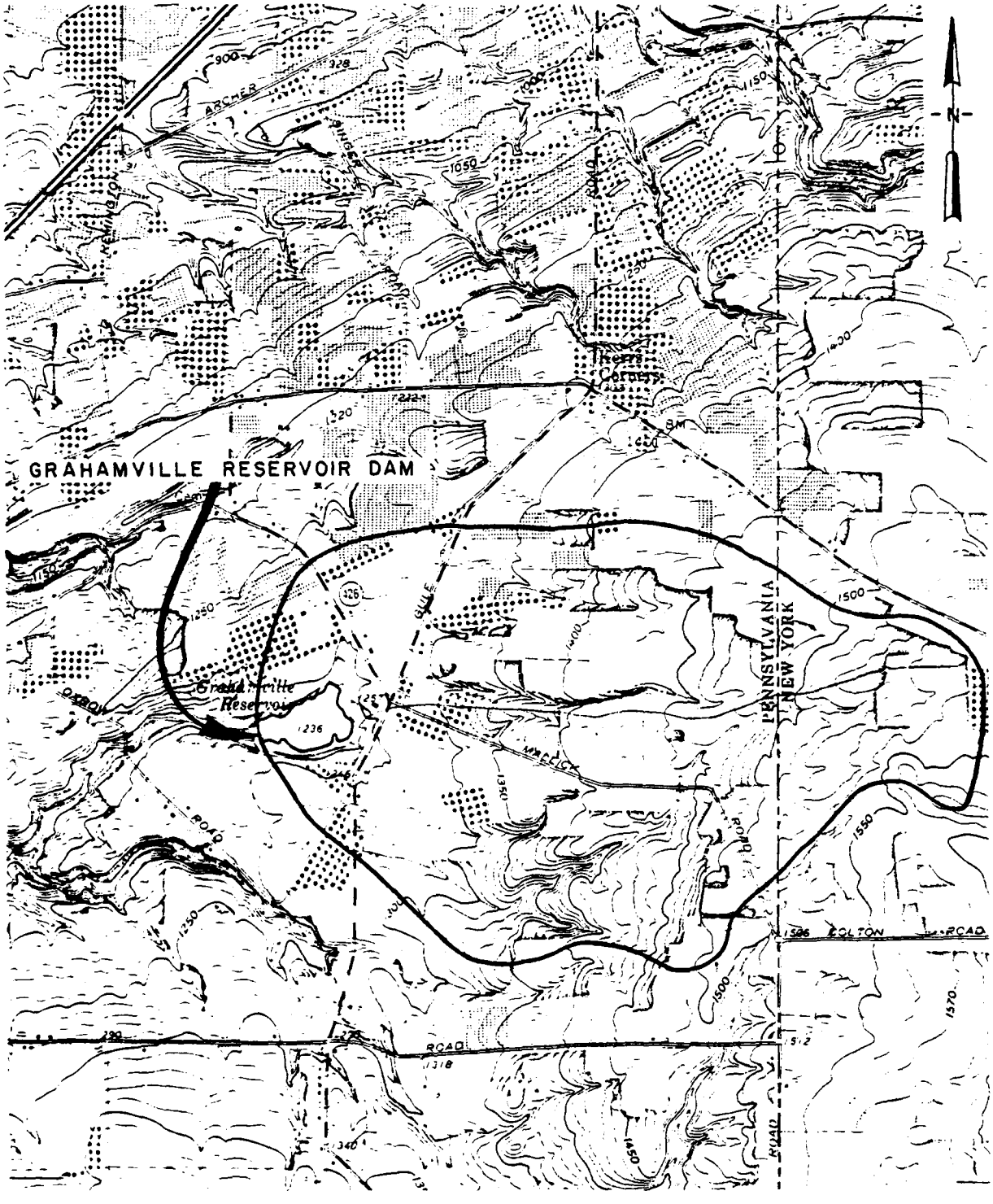
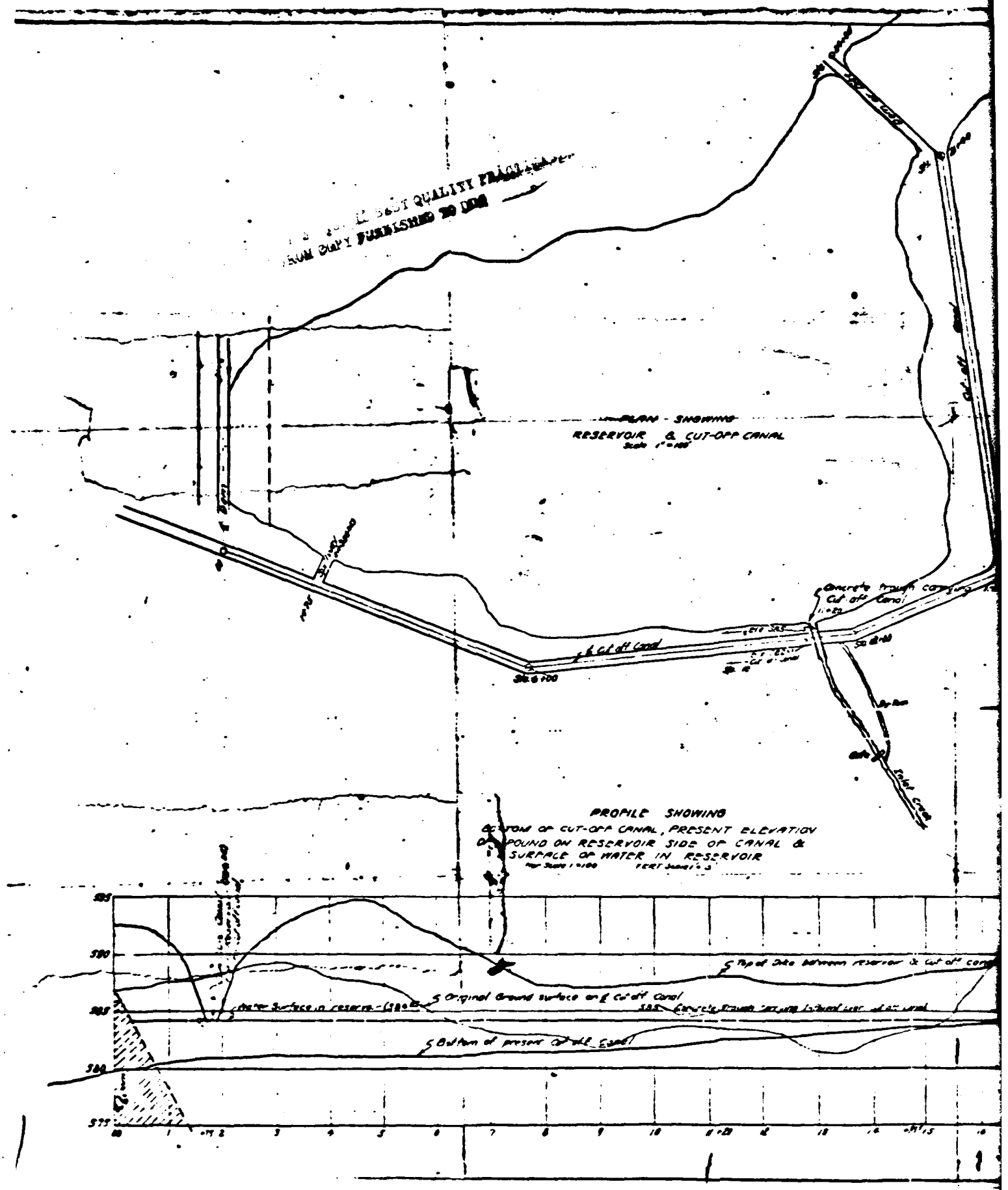


PLATE 2 WATERSHED MAP

GRAHAMVILLE RESERVOIR DAM


PLAN - SHOWING
RESERVOIR & CUT-OFF CANAL
Scale 1" = 100'
Concrete trough conveying
Cut off Canal
℄ Cut off Canal
PROFILE SHOWING
BOTTOM OF CUT-OFF CANAL, PRESENT ELEVATION
OF GROUND ON RESERVOIR SIDE OF CANAL &
SURFACE OF WATER IN RESERVOIR
Horz Scale 1"=100'
Vert Scale 1"=5'
℄ Top of Dike between reservoir & cut off canal
℄ Original Ground surface on ℄ Cut off Canal
Water Surface in reservoir - 1580 Ft
℄ Bottom of present Cut off Canal

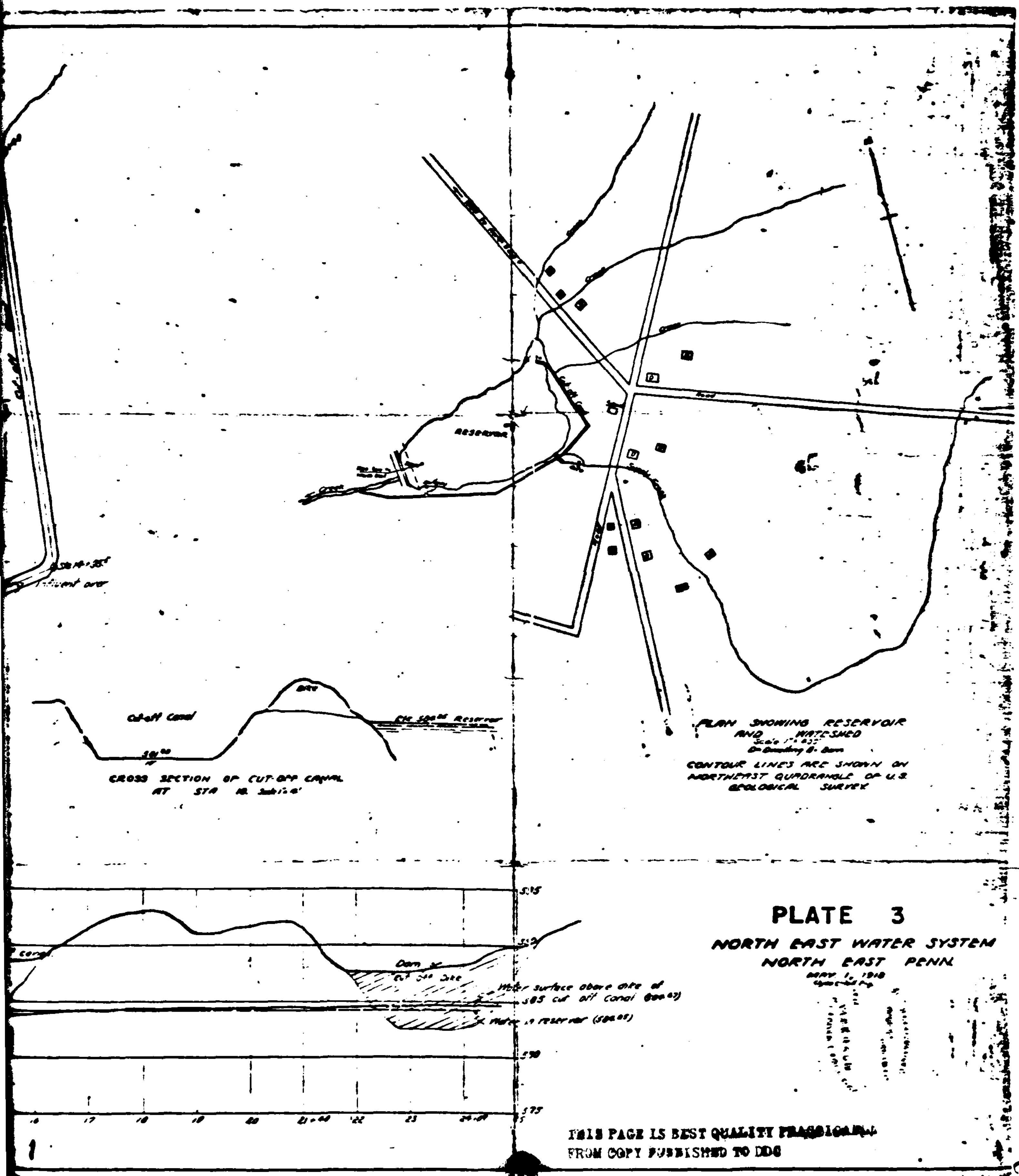
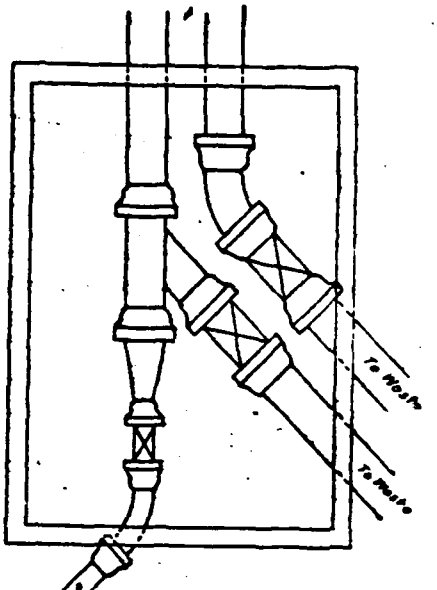


PLATE 3

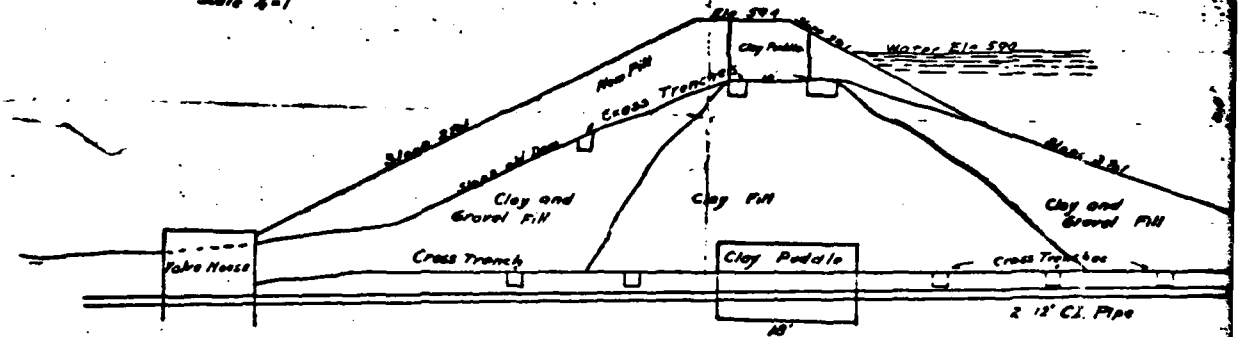
NORTH EAST WATER SYSTEM

NORTH EAST PENN.

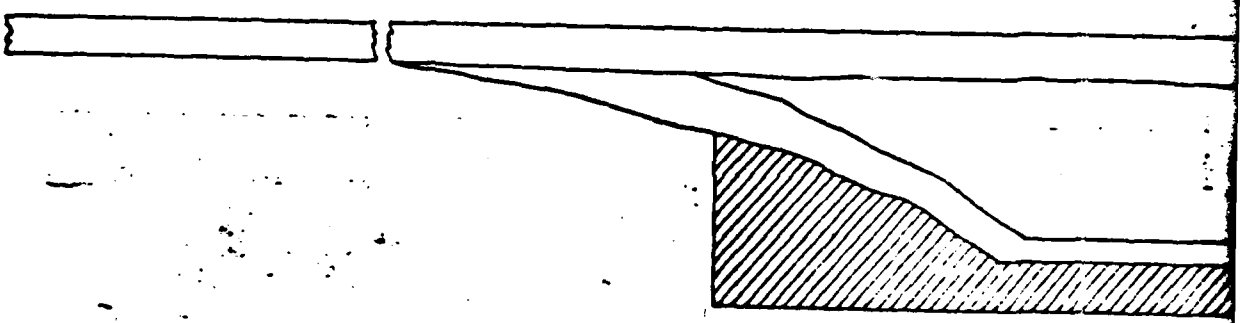
MAY 1, 1916

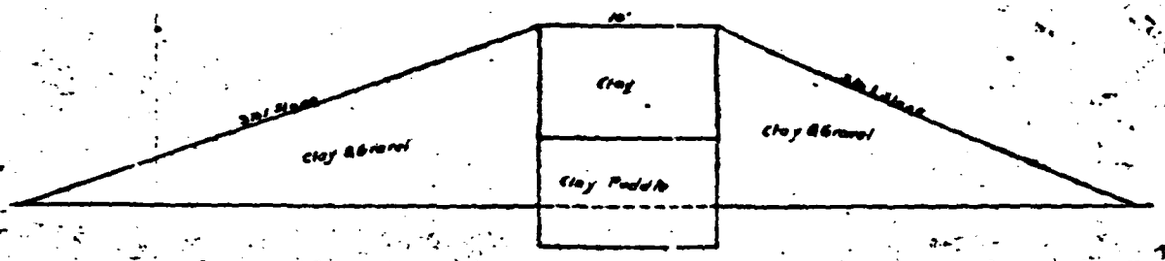


Valve House
Scale 4"=1'

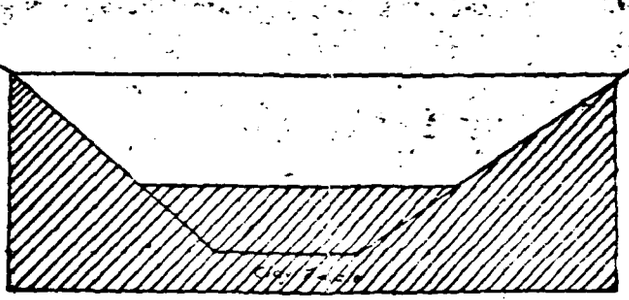


Cross Section of Dam
Scale 1"=10'





Cross Section of Canal Fill



Longitudinal Section of Canal Fill

Scale 1"=4'

Outlet Pipes Concreted in place

Longitudinal Section of Dam

Scale 1"=10'

PLATE 4

NORTH EAST BORO

Water Department

Grahamville Reservior Extension

October 1923

Scales as Noted

Hill & Hill Engs.

2

APPENDIX A

CHECK LIST - VISUAL INSPECTION AND FIELD SKETCHES

Check List
Visual Inspection
Phase 1

Name of Dam Grahamville Reservoir Dam County Erie State PA Coordinates Lat. N 42° 11.0'
NDI # PA 00020
PennDER # 25-2 Long. W 79° 47.3'

Date of Inspection 16 November 1978 Weather Partly cloudy Temperature 50°F.

Pool Elevation at Time of Inspection 1235.28 ft.* M.S.L.
Tailwater at Time of Inspection 1204.78 ft.* M.S.L.

*Elevations are based on invert elevation of emergency spillway from plans and correction of +653.03 ft. to convert from plan datum based on North East Borough datum and USGS elevations.

Inspection Personnel:

Michael Baker, Jr., Inc.:

Rodney E. Holderbaum
David Johns
James G. Ulinski

Site Visit - 5 June 1979

C. Y. Chen
James G. Ulinski

Owner's Representatives
North East Borough, PA:

Herb Mallick, Engineer

David Johns Recorder

CONCRETE/MASONRY DAMS - Not Applicable

Name of Dam: GRAHAMVILLE RESERVOIR DAM
NDI # PA 00020

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
LEAKAGE		
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS		
DRAINS		
WATER PASSAGES		
FOUNDATION		

CONCRETE/MASONRY DAMS - Not Applicable

Name of Dam: GRAHAMVILLE RESERVOIR DAM
NDI # PA 00020

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES		
STRUCTURAL CRACKING		
VERTICAL AND HORIZONTAL ALIGNMENT		
MONOLITH JOINTS		
CONSTRUCTION JOINTS		

Name of Dam: GRAHAMVILLE RESERVOIR DAM
NDI # PA 00020

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None observed	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	1. Erosion has cut into the upstream face creating a 3-4 ft. near vertical drop-off at normal pool. 2. Erosion was also noted at approximately 200 ft. from the right abutment on the downstream face. 3. The crest has two large ruts across the top due to vehicular traffic.	1. The upstream face should be regraded to a flatter slope and riprap should be placed to prevent erosion. 2. The eroded areas should be regraded, treated and seeded with an appropriate mixture to prevent erosion. 3. The crest should be regraded, treated and seeded with an appropriate mixture to prevent erosion. Vehicular traffic should be prohibited on the crest on the embankment.
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	No misalignment of the crest was noted.	
RIPRAP FAILURES	Very little riprap was noted on the upstream face. The majority of the area is covered with weeds and bushes.	It is recommended that the upstream face be cleared of all vegetation, the slope regraded to a flatter slope and riprap be placed to prevent erosion.

EMBANKMENT

Name of Dam: GRAHAMVILLE RESERVOIR DAM
NDI # PA 00020

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	No problems were observed.	
ANY NOTICEABLE SEEPAGE	Along the right abutment, a significant (1-2 g.p.m.) amount of seepage was noted; however, due to the dense vegetative growth along the downstream face, no assessment could be made as to the severity of the seepage.	The downstream face should be cleared and grubbed for a distance of 10 ft. beyond the toe and another inspection should be scheduled at a later date. A qualified engineer should be engaged to determine the severity of the seepage and its effects on the structural stability of the dam.
STAFF GAGE AND RECORDER	None installed	
DRAINS	None installed	

OUTLET WORKS

Name of Dam: GRAHAMVILLE RESERVOIR DAM
NDI # PA 00020

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT		
INTAKE STRUCTURE	The intake structure was completely submerged; therefore, no assessment could be made.	
OUTLET STRUCTURE	1. The concrete structure around the outlet pipes has collapsed. 2. The concrete gate valve house is badly cracked and spalled.	1. The outlet head wall structure should be repaired. 2. The concrete should be repaired.
OUTLET CHANNEL	The valley below the dam becomes a narrow gorge; the floor of which is composed of slate. The side slopes are steep and covered with second growth timber and shrubs.	
EMERGENCY GATE	None installed	

Name of Dam: GRAHAMVILLE RESERVOIR DAM
NDI # PA 00020

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Not Applicable	
APPROACH CHANNEL	1. The approach channel flows through the left bank of the reservoir, approximately 175 ft. upstream of the dam. The typical cross-section would be 6 ft. bottom width, 10 ft. deep with 1H:1V side slope.	
	2. At the beginning of the channel, three 8-in. C.I.P. are installed beneath the access road for low flows. Debris has collected in front of these pipes.	2. The pipe entrances should be cleared.
	3. The approach channel between the access road and discharge channel is overgrown with brush.	3. The channel should be cleared.
DISCHARGE CHANNEL	The spillway empties into the diversion or cutoff channel around the dam. The channel is overgrown with brush and has extensively eroded the underlying rock formation.	All brush should be removed from the channel.
BRIDGE AND PIERS	None	
DIVERSION CHANNEL	The diversion channel is overgrown with brush and small trees. Some debris is obstructing the channel at several locations.	All vegetation and debris should be periodically removed from the channel.

GATED SPILLWAY - Not Applicable

Name of Dam: GRAHAMVILLE RESERVOIR DAM
NDI # PA 00020

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL		
APPROACH CHANNEL		
DISCHARGE CHANNEL		
BRIDGE AND PIERS		
GATES AND OPERATION EQUIPMENT		

INSTRUMENTATION - None Installed

Name of Dam: GRAHAMVILLE RESERVOIR DAM
NDI # PA 00020

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS		
OBSERVATION WELLS		
WEIRS		
PIEZOMETERS		
OTHER		

RESERVOIR

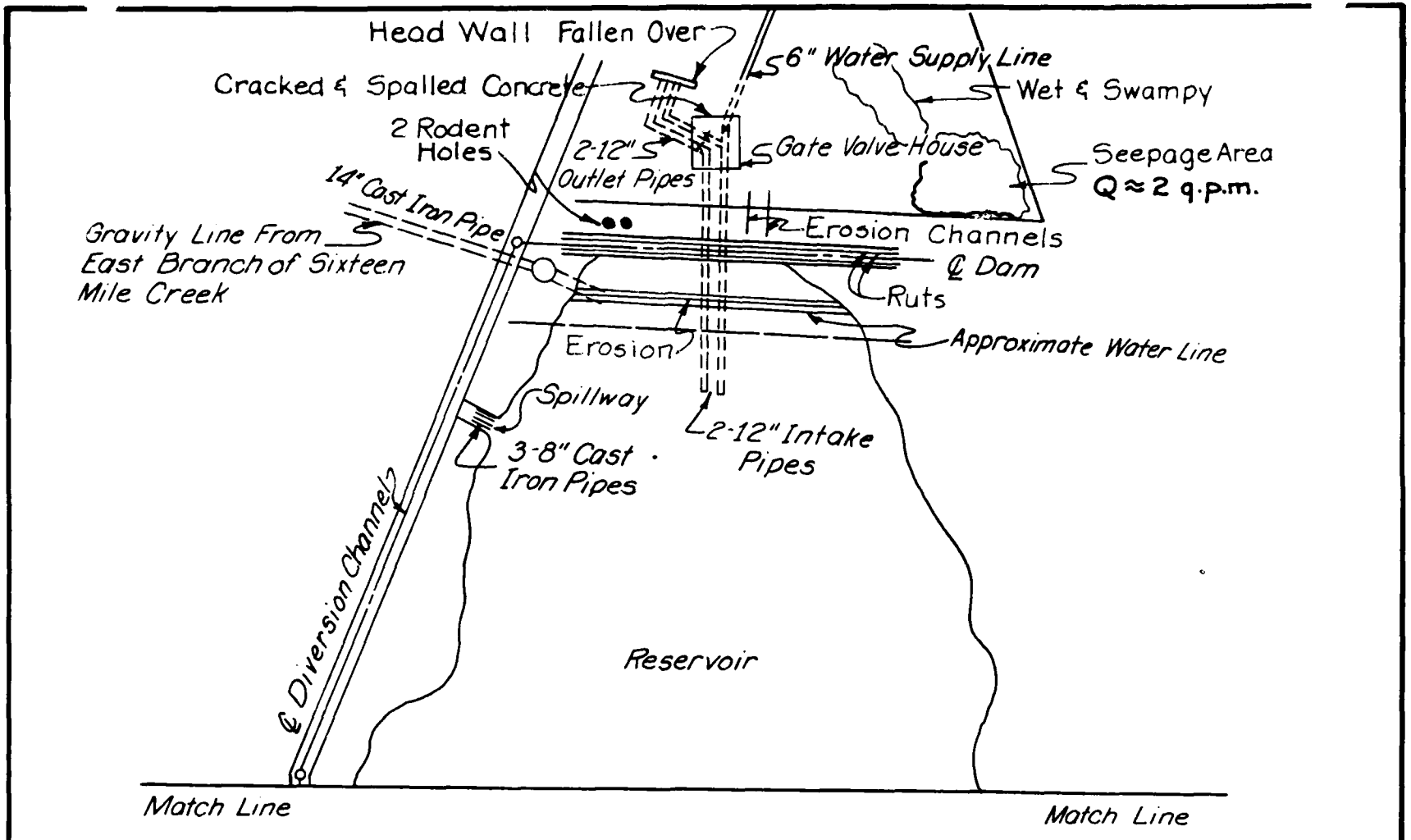
Name of Dam: GRAHAMVILLE RESERVOIR DAM
NDI # PA 00020

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	The upstream area is a cultivated rolling countryside; the greater percentage of which is used for growing fruit. The remaining areas (the tops of hills) are wooded.	
SEDIMENTATION	Since inflows to the reservoir are limited by the three conduits, it is doubtful that any extensive sedimentation has occured.	

DOWNSTREAM CHANNEL

Name of Dam: GRAHAMVILLE RESERVOIR DAM
NDI # PA 00020

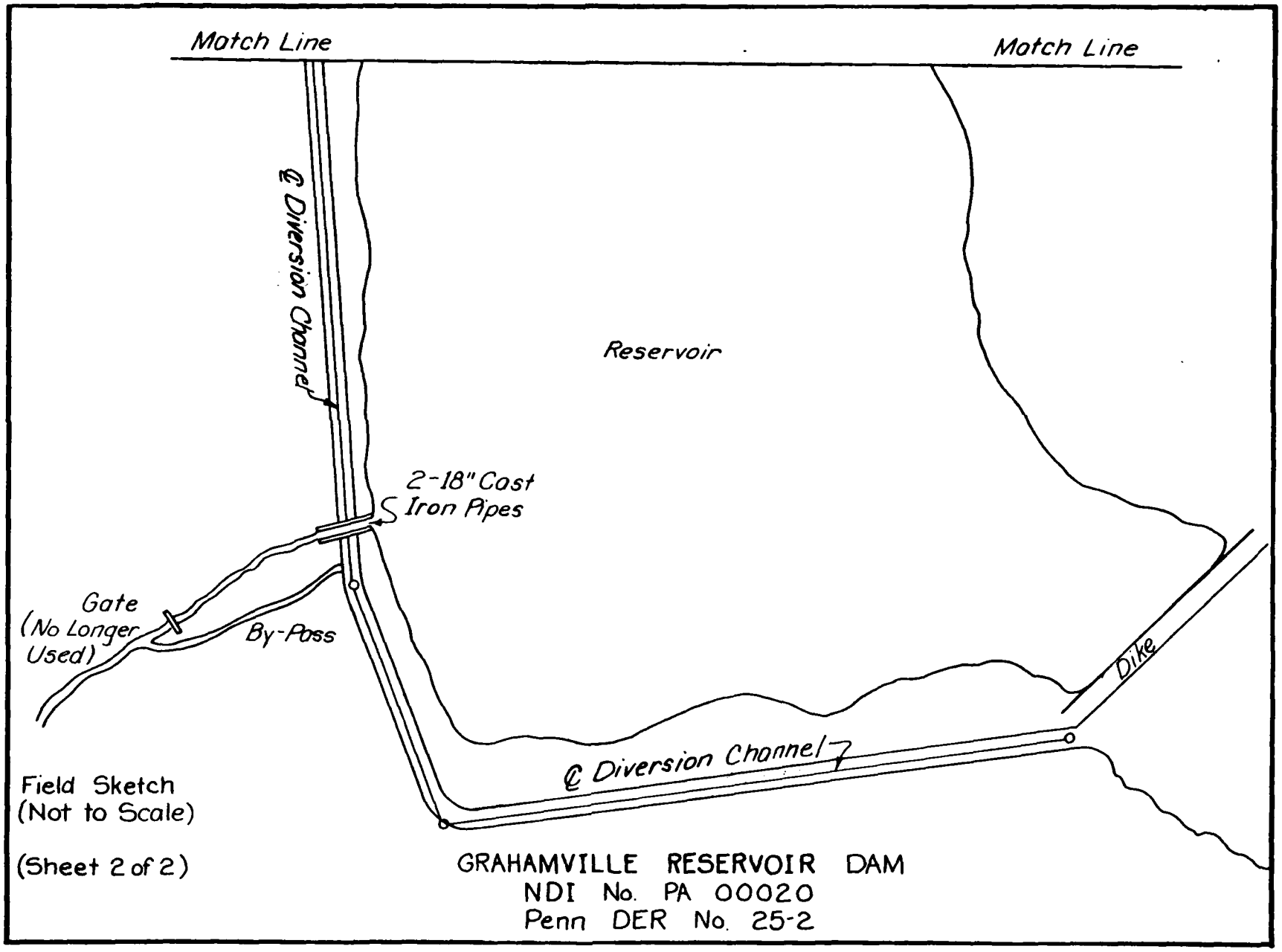
VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Sixteen Mile Creek flows through a forested area downstream from the dam. No major obstructions are located in the floodplain.	
SLOPES	The slope of the downstream channel is relatively steep, averaging approximately 2%. The slopes adjacent to the stream channel are steep and primarily forested.	
APPROXIMATE NO. OF HOMES AND POPULATION	The nearest homes are located about 4 mi. downstream from the dam in North East, Pennsylvania.	



Field Sketch
(Not to Scale)

(Sheet 1 of 2)

GRAHAMVILLE RESERVOIR DAM
NDI No. PA 00020
Penn DER No. 25-2



(Sheet 2 of 2)

GRAHAMVILLE RESERVOIR DAM
NDI No. PA 00020
Penn DER No. 25-2

APPENDIX B

CHECK LIST - ENGINEERING DATA

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

Name of Dam: GRAHAMVILLE RESERVOIR DAM
NDI # PA 00020

ITEM	REMARKS
PLAN OF DAM	See Plate 3.
REGIONAL VICINITY MAP	A portion of the North East, Pennsylvania 7.5 minute quadrangle map showing the location of the dam with state location inset is enclosed in this report as Plate 1.
CONSTRUCTION HISTORY	None available
TYPICAL SECTIONS OF DAM	See Plate 4.
HYDROLOGIC/HYDRAULIC DATA	See Check List - Engineering Data, page B-4, and also Appendix D.
OUTLETS - PLAN	See Plate 4.
- DETAILS	None available
- CONSTRAINTS	Two-12 in. C.I.P.
- DISCHARGE RATINGS	None available
RAINFALL/RESERVOIR RECORDS	None available

Name of Dam: GRAHAMVILLE RESERVOIR DAM
NDI # PA 00020

ITEM	REMARKS
DESIGN REPORTS	None available
GEOLOGY REPORTS	See Appendix E, Regional Geology
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None available
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	None available
POST-CONSTRUCTION SURVEYS OF DAM	Information received from Hill and Hill Engineers of North East, Pa., indicates the existence of bench mark located at the base of the control gate. The gate is located approximately 850 ft. upstream of the main embankment. This information was not verified in the field due to the fact that it was not obtained until after the field inspection.
BORROW SOURCES	None available

Name of Dam: GRAHAMVILLE RESERVOIR DAM

NDI # PA 00020

ITEM	REMARKS
MONITORING SYSTEMS	None installed
MODIFICATIONS	Additional material was placed on both the diversion dike and embankment in the late 1920's. In the early 1930's a 14 in. C.I.P. was installed as a gravity feed into the reservoir from the East Branch of Sixteen Mile Creek. The flume across the bypass canal was replaced by two 18 in. C.I.P. and three 8 in. C.I.P. were placed in the emergency spillway channel to permit vehicular traffic across the channel.
HIGH POOL RECORDS	None available
POST-CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None available
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None reported
MAINTENANCE OPERATION RECORDS	None available

Name of Dam: GRAHAMVILLE RESERVOIR DAM
NDI # PA 00020

ITEM	REMARKS
SPILLWAY PLAN, SECTIONS, and DETAILS	None available
OPERATING EQUIPMENT PLANS & DETAILS	None installed

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 1.64 sq.mi. (primarily farmland)

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 1237.28 ft. (140 ac.-ft.)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): 1242.57 ft. (209 ac.-ft.)

ELEVATION MAXIMUM DESIGN POOL: Unknown

ELEVATION TOP DAM: 1242.57 ft.

CREST: Emergency Spillway

a. Elevation 1237.28 ft.
b. Type Three 8-in. C.I.P. under road to earth channel
c. Width Approximately 6 ft.
d. Length 162 ft.
e. Location Spillover 175 ft. upstream from dam
f. Number and Type of Gates None

OUTLET WORKS: Principal Spillway

a. Type Two 12 in. C.I.P.
b. Location Submerged above upstream toe
c. Entrance inverts 12 in. blow-off pipe - El. 1218.03 ft.
12 in. service - El. 1220.53 ft.
d. Exit inverts El. 1204.78± ft.
e. Emergency draindown facilities Two 12 in. gate valves located in gate house on downstream slope

HYDROMETEOROLOGICAL GAGES: None

a. Type
b. Location
c. Records

MAXIMUM NON-DAMAGING DISCHARGE Unknown

APPENDIX C

PHOTOGRAPHS

DETAILED PHOTOGRAPH DESCRIPTIONS

Overall View of Dam Looking Left to Right along Upstream Slope

Photo 1 - Approach Channel of Emergency Spillway

Photo 2 - Three 8 inch Pipes that Carry Emergency Spillway Flow under Dirt Road (Note Debris Obscuring Middle Pipe.)

Photo 3 - Outlet Channel of Emergency Spillway Looking from Diversion Channel Back Toward Reservoir

Photo 4 - Main Embankment from Right Abutment (Note Ruts and Standing Water on Crest.)

Photo 5 - Downstream Side of Dam (Note Fallen Head Wall over 12 inch Outlet Pipes. Gate Valve House is Shown in Background.)

Photo 6 - Close up of Gate Valve House (Note Deteriorated Condition of Concrete.)

Photo 7 - View of Reservoir from Crest

Photo 8 - Diversion Channel around Left End of Reservoir

Photo 9 - Inlet to Reservoir (Two 18 inch Cast-Iron Pipes.)

Photo 10 - Reservoir End of Two 18 inch Cast-Iron Pipes

Photo 11 - Seepage Area along Downstream Right Abutment of Dam

Note: Photos 1-10 were taken on 16 November 1978 and Photo 11 was taken on 5 June 1979.

GRAHAMVILLE RESERVOIR DAM

PHOTO 1. Approach Channel of Emergency Spillway

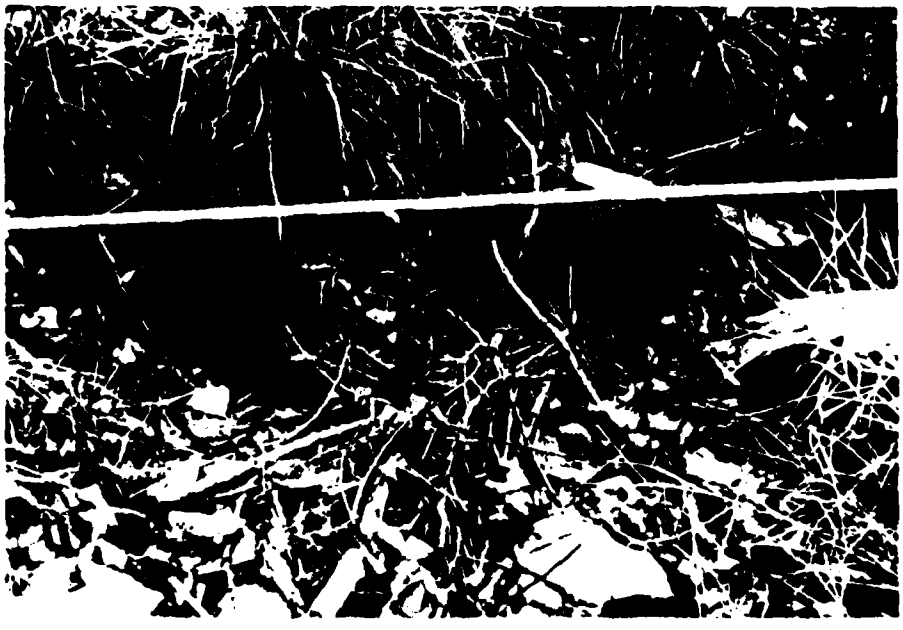


PHOTO 2. Three 8 inch Pipes that Carry Emergency Spillway Flow under Dirt Road (Note Debris Obscuring Middle Pipe)

PHOTO 3. Outlet Channel of Emergency Spillway Looking from Diversion Channel Back Toward Reservoir

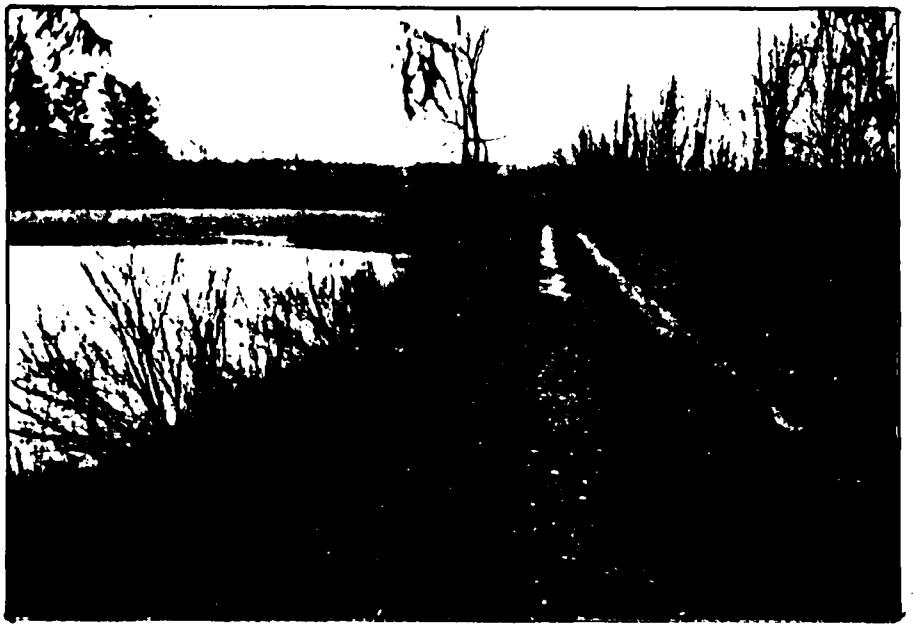


PHOTO 4. Main Embankment from Right Abutment (Note Ruts and Standing Water on Crest)

PHOTO 5. Downstream Side of Dam
(Note Fallen Head Wall over 12 inch Outlet Pipes.
Gate Valve House is Shown in Background)

PHOTO 6. Close-up of Gate Valve House
(Note Deteriorated Condition of Concrete)

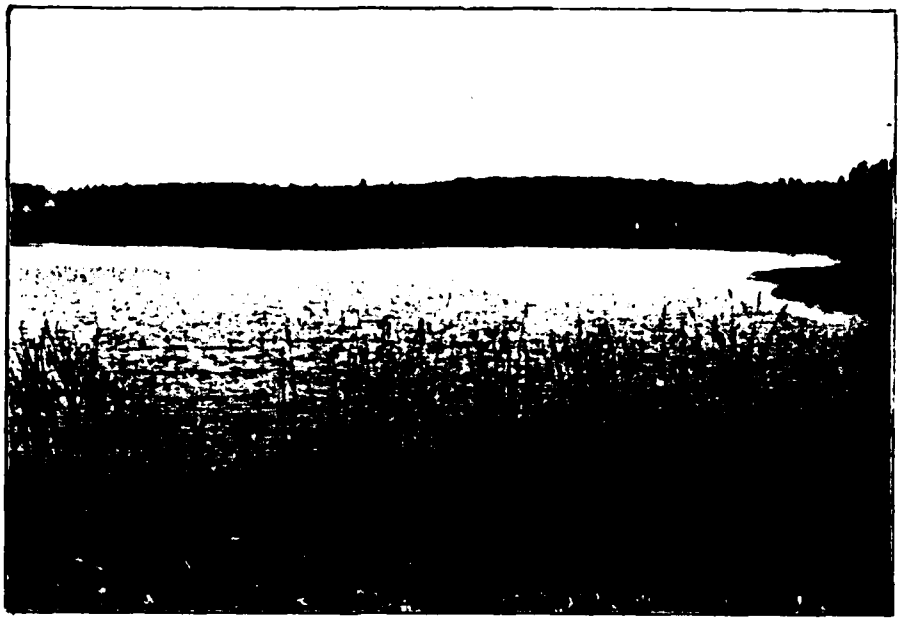


PHOTO 7. View of Reservoir from Crest

PHOTO 8. Diversion Channel around Left End of Reservoir

PHOTO 9. Inlet to Reservoir (Two 19 inch Cast-Iron Pipes)

PHOTO 10. Reservoir End of Two 18 inch Cast-Iron Pipes

GRAHAMVILLE RESERVOIR DAM

PHOTO 11. Seepage Area along Downstream Right Abutment of Dam

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject Grahamville Dam S.O. No. _____
Hydrology and Hydraulics Sheet No. ____ of ____
Drawing No. _____
Computed by REH Checked by _____ Date _____

Table of Contents

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject Grahamville Dam S.O. No.
Introduction Sheet No. 1 of 32
Drawing No.
Computed by REH Checked by Date

Grahamville Dam is a small-size significant hazard dam requiring evaluation for a 100-year flood. A dyke has been constructed around the entire reservoir thus cutting off most of the drainage area. Inflows to the reservoir could include:

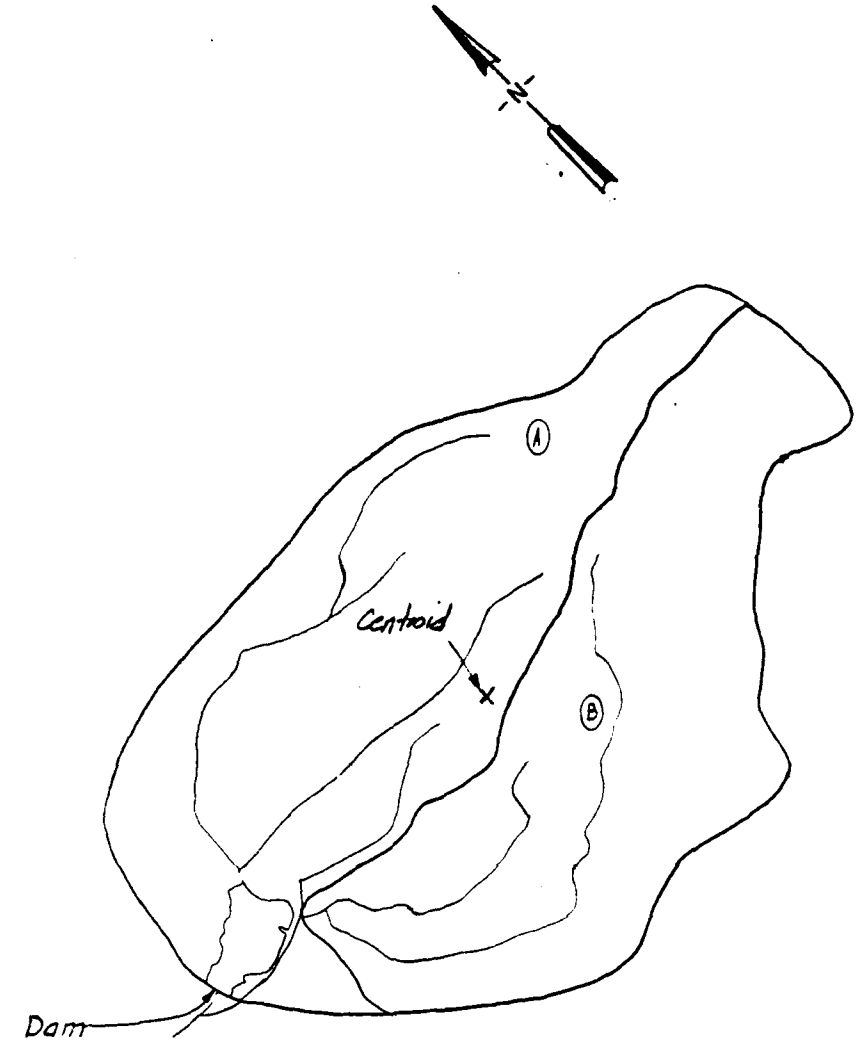
1. Flows entering the reservoir through the three inlet pipes. (see page 4)
2. Flows overtopping the dyke in the event that the diversion channel capacity is exceeded by the 100-year flood.

The methods used to hydrologically and hydraulically evaluate the dam are as follows.

1. The peak flows for the 100-year storm were estimated using the SCS method for agricultural (non-urbanized) areas as outlined in Technical Release No. 55.
2. Possible inflows to the reservoir were evaluated by calculating the capacities of the diversion channel and pipes entering the reservoir.
3. The capacity of the spillway was calculated to determine if it is of

sufficient size to adequately convey all inflows to the reservoir to the downstream channel.

Dimensions of the diversion channel, inflow pipes, and spillway were determined from design plans and approximate field surveys taken during the field inspection.

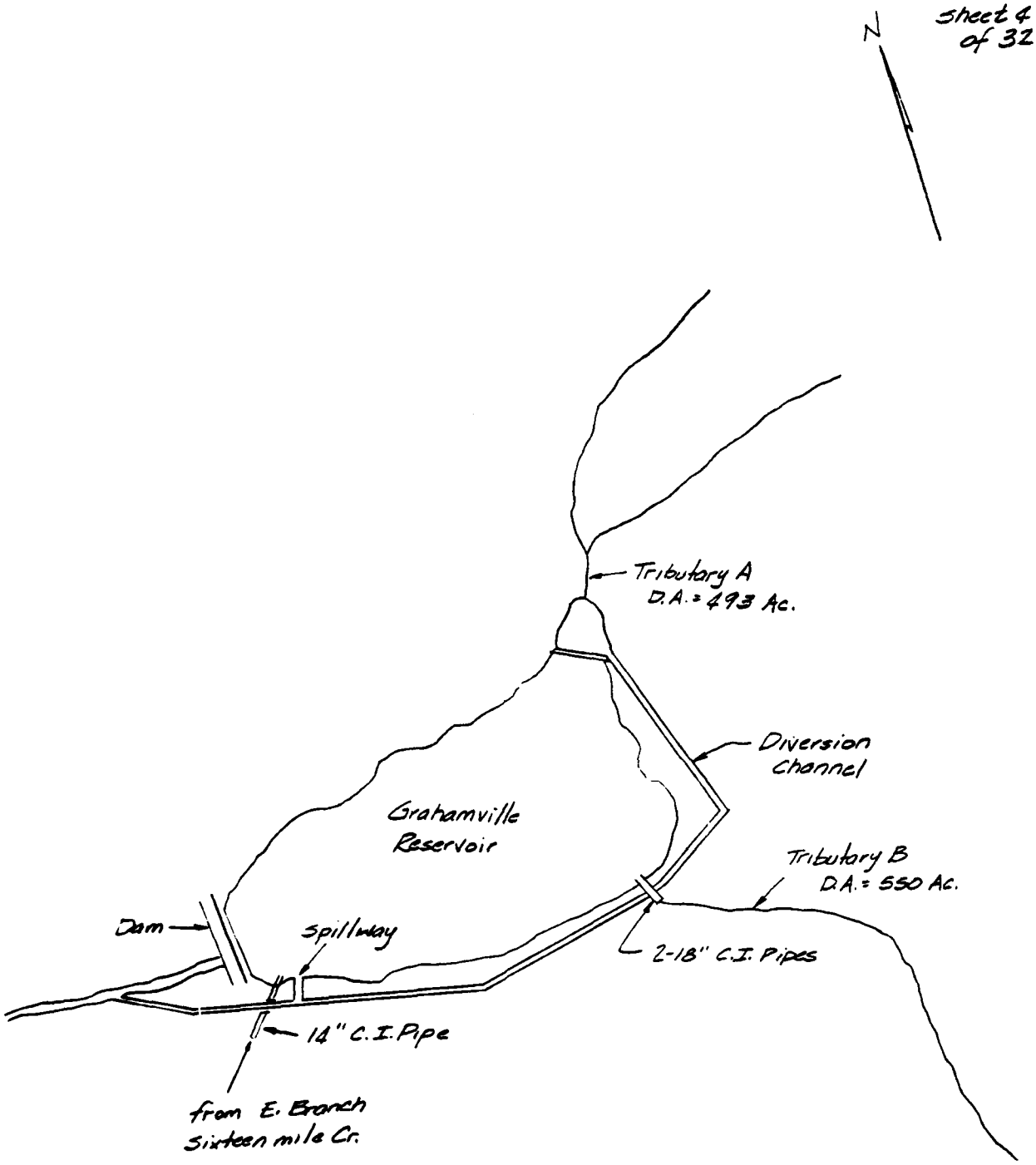


Quad: North East
A. Drainage Area = 0.77 mi.²
L = 2.22 mi. s = 2.56%
B. Drainage Area = 0.87 mi.²
L = 2.12 mi. s = 2.68%
Total Drainage Area = 1.64 mi.²

SCALE: 1" = 2000'
DATE: 3-29-79 ccs

Grahamville Reservoir
Watershed

MICHAEL BAKER JR. INC.
Consulting Engineers & Surveyors



GRAHAMVILLE DAM
AND RESERVOIR

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject Grahamville Dam S.O. No.
Hydrology and Hydraulics Sheet No. 5 of 32
Drawing No.
Computed by REH Checked by Date 6-16-79

Estimate 100-year storm runoff:

This analysis was taken from Technical Release 55 published by the Soil Conservation Service. See Chapter 4 and App. D and E. This method is applicable to non-urbanized watershed less than 2000 acres in size. A type II rainfall distribution is assumed.

Sub-basin A:

D.A. = 493 ac.

Watershed slope = 2.6 %

100 year rainfall = 4.8 inches (pg. C-5)

Curve No:

Soils in the area are primarily in hydrologic group C (soil name - Volusia). The land use in the watershed is estimated from the Northeast quad. map (7½ min.) as follows:

Land use	Percent	CN*
Meadows	50	71
Wooded	40	74
Cultivated	10	83

* From table 2-2

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject Grahamville Dam — S.O. No.
Hydrology and Hydraulics — Sheet No. 6 of 32
Drawing No.
Computed by REH — Checked by — Date 6-16-79

The weighted CN for sub-basin A
= 0.5(71) + 0.4(74) + 0.1(83) ≈ 73

From figure D-2 (Peak rates of discharge for small watersheds)

Q = 95 cfs/inch runoff (1% w/s slope)

The adjustment factor for a w/s with a 2.6 % slope = 1.4 (Table E-1)

Q = 95 (1.4) ≈ 135 cfs/inch runoff

Total runoff from 4.8 inches rainfall
= 2.1 inches (Table 2-1 with CN = 73)

Therefore Q_{100} = 135(2.1) = 285 cfs.

Sub-basin B:

D.A. = 550 ac.
Watershed slope = 2.7 %
100-year rainfall = 4.8 inches
Curve Number: (Hydrologic Soil Group C)

Land Use	Percent	CN
Meadows	35	71
Wooded	60	74
Cultivated	5	83

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject Grahamville Dam — S.O. No.
Hydrology and Hydraulics — Sheet No. 7 of 32
Drawing No.
Computed by REH — Checked by — Date 6-16-79

The weighted CN for sub-basin B
= 0.35 (71) + 0.6 (74) + 0.05 (83) = 73

From figure D-2:

Q = 100 cfs/in. runoff (1% w/s slope)

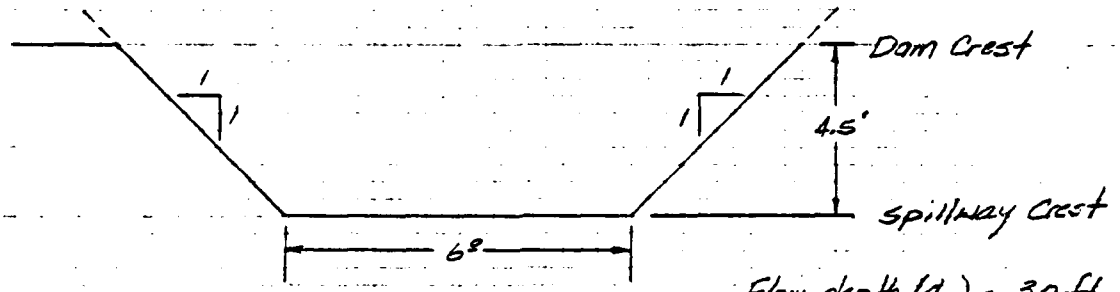
The adjustment factor for a 2.7% w/s slope = 1.4 (Table E-1)

Q = 100 (1.4) = 140 cfs/in. runoff

Therefore Q_{100} = 140 (2.1) = 295 cfs.

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS
Box 280
Beaver, Pa. 15009

Subject Grahamville Reservoir — S.O. No.
Spillway and Diversion — Sheet No. 8 of 32
Channel Capacities — Drawing No.
Computed by REH — Checked by — Date 3-16-79



Flow depth (d_c) = 3.0 ft.
Head velocity = 1.5 ft
Total head = 4.5 ft.

Maximum spillway capacity:
(assume critical depth)

z (section factor) $= A\sqrt{A/T}$ — A = flow area, T = top width

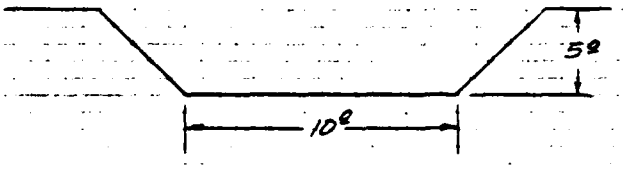
$z = 27.0\sqrt{27.0/12} = 40.5$

$Q = z\sqrt{g} = 40.5\sqrt{32.2} = 230$ cfs. ← Maximum spillway capacity

(Source: Open Channel Hydraulics - Ven Te Chow)

Diversion Ditch Capacty:

a. Capacity at confluence with tributary A



Side slopes = 1:1

$Q = \frac{1.49}{n} R^{2/3} S^{1/2} A$ — Assuming uniform flow conditions

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject Grahamville Reservoir S.O. No.
Diversion channel capacity Sheet No. 9 of 32
Drawing No.
Computed by REH Checked by Date 3-16-79

n = 0.05 (Brush lined channel - relatively straight and uniform in cross-section)

A = 75 ft.²

S ≈ 0.003

$$Q = \frac{1.49}{0.05}\left(\frac{75}{24.1}\right)^{2/3}(0.003)^{1/2}\,75 = 260 \text{ cfs}$$

b. Capacity at confluence with Tributary B

depth = 8.5 ft. side slopes = 1:1
bottom width = 10 ft.

$$Q = \frac{1.49}{0.05}\left(\frac{157.2}{34.0}\right)^{2/3}(0.003)^{1/2}\,157.2 = 710 \text{ cfs.}$$

c. Capacity at confluence with spillway

depth = 12 ft. side slopes = 1:1
bottom width = 10 ft.

$$Q = \frac{1.49}{0.05}\left(\frac{264}{44}\right)^{2/3}(0.003)^{1/2}\,264 = 1420 \text{ cfs.}$$

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject Grahamville Dam — S.O. No. ____
Hydrology and Hydraulics — Sheet No. 10 of 32
Drawing No. ____
Computed by ____ Checked by ____ Date ____

Inflow to Grahamville Reservoir through inlet pipes:

(1) 14 inch cast iron pipe

$$Q = \frac{1.49}{n} R^{2/3} S^{1/2} A$$

assuming uniform flow and full flow condition.

slope = 0.02 ft/ft.

$$Q = \frac{1.49}{0.012}\left(\frac{1.07}{3.67}\right)^{2/3}(0.02)^{1/2}(1.07) = 8 \text{ cfs.}$$

(2) 2 - 18 inch cast iron pipes

$$Q = \frac{1.49}{n} R^{2/3} S^{1/2} A$$

Slope = 0.02 ft/ft.

$$Q = 2\left(\frac{1.49}{0.012}\right)\left(\frac{1.77}{4.71}\right)^{2/3}(0.02)^{1/2}(1.77) = 32 \text{ cfs.}$$

Total inflow from three pipes = 40 cfs.

The potential for overtopping the dyke adjacent to the diversion channel should be evaluated at three locations. Inflows to the reservoir through the three inlet pipes will also be considered.

(1) At confluence of Tributary A and diversion channel.

Runoff from sub-basin A = 285 cfs.
Diversion channel capacity = 260 cfs.
Therefore approximately 25 cfs. will overtop the dyke and flow into the reservoir at this point.

(2) At confluence of Tributary B and diversion channel.

Discharge from sub-basin A (diversion channel capacity at (1) above) = 260 cfs.
Runoff from sub-basin B = 295 cfs.
Total 555 cfs.
Diversion channel capacity = 710 cfs.

Since the diversion channel capacity exceeds the total expected discharge at this location the dyke should not be overtopped. However, approximately 32 cfs. will enter the reservoir through the

two 18" C.I. pipes.

(3) At the confluence of the spillway and diversion channel.

Total inflow to reservoir from (1) & (2) on previous page = 57 cfs.

Inflow through 14" C.I. pipe = 8 cfs.

Total inflow to reservoir = 65 cfs.

Spillwall Capacity = 230 cfs.

The spillway, therefore, has sufficient capacity to pass the 100-year flood. Since the capacity of the diversion channel (at the spillway) is 1420 cfs. no overtopping of the dyke or restriction of flows from the spillway would be expected.

Effects of overtopping of dyke at the confluence of tributary A and diversion channel.

Length of dyke subject to overtopping ≅ 150 ft. Assume, however, that only 20 ft. of the dyke is overtopped.

$\therefore Q = 25 \text{ cfs.} = CLH^{3/2}$

$25 = 2.65(20)H^{3/2} \Rightarrow H \approx 0.6 \text{ ft.}$

(Not sufficient to cause failure of the dyke)

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject Grahamville Dam S.O. No.
Conclusions Sheet No. 13 of 32
Drawing No.
Computed by REH Checked by Date

The results of this evaluation indicate that the dam would not be overtopped by the 100-year flood. Several conditions or assumptions used in the analysis are as follows:

1. The crest of the diversion dyke is at approximately the same elevation as the crest of the dam.
2. The storage capacity of the reservoir was neglected. (In reality, the storage will be affected slightly by rainfall directly on the reservoir.)
3. All discharges in excess of the capacity of the diversion channel will enter the reservoir.

These assumptions are, overall, probably somewhat conservative and therefore support the conclusion that the dam is capable of passing the 100-year flood without overtopping.

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject Grahamville Dam
Spillway Rating
S.O. No.
Sheet No. 14 of 32
Drawing No.
Computed by REH Checked by Date 8-15-79

W.S. Elev. (ft.)	Area (ft²)	T (ft.)	Z	Q (cfs.)	Res. Elev. (ft.)
1238.6		6.0		0	12386
1239.0	2.56	6.8	1.57	9	1239.2
1240.0	10.36	8.8	11.24	64	1240.7
1241.0	20.16	10.8	27.54	156	1242.2
1242.0	31.96	12.8	50.50	287	1243.7
1243.0	45.76	14.8	80.46	457	1245.2

Also see pg. of this appendix

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject Grahamville Dam — S.O. No.
Hydrology and Hydraulics — Sheet No. 15 of 32
Drawing No.
Computed by REH — Checked by — Date 8-16-79

Rainfall Data:

From HMR 33: Zone 2

$P(24\ hr. - 200\ sq.\ mi.) = 22.9\ in.$

$P_6 = 117\%\ P_{24-200}$

$P_{12} = 127\%\ P_{24-200}$

$P_{24} = 141\%\ P_{24-200}$

$P_{48} = 151\%\ P_{24-200}$

Hydrograph Data: (Snyder's unit hydrograph)

The following average values were determined from the two major watercourses tributary to the reservoir.

$L = 2.17\ mi.$ $L_{ca} = 0.99\ mi.$

The w/s is in zone 26 $\Rightarrow$ $C_p = 0.78$

$C_t = 1.16$

$\therefore t_p = 1.16\,[(2.17)(0.99)]^{0.3}$

$t_p = 1.46\ hours$

$t_r = 1.46/5.5 = 0.27\ hr.$ use $t_R = 0.5\ hr.$

$\therefore t_{pR} = 1.46 + 0.25(0.5 - 0.27)$

$t_{pR} = 1.52\ hours$

```
****  **************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
  MBJ UPDATE         04 JUN 79
**********************************
     1              A1       NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
     2              A2       HYDROLOGIC AND HYDRAULIC ANALYSIS OF GRAHAMVILLE RES. MBJ  06
     3              A3       PROBABLE MAXIMUM FLOOD PMF/UNIT GRAPH BY SNYDERS METHOD
     4              B    200        0       30        0        0        0        0        0        0        0
     5              B1     5
     6              J      1        1        1
     7              J1   0.5
     8              K      0        1                                                  1
     9              K1       STORM HYDROGRAPH DEVELOPMENT BY SNYDERS UNIT HYDROGRAPH
    10              M      1        1     1.64
    11              P              22.9      117      127      141      151
    12              T                                                          1.0     0.05
    13              W   1.52     0.78
    14              X   -1.5    -0.05      2.0
    15              K     99
```

Sheet 16 of 32

```
**********
FLOOD  ROGRAPH PACKAGE (HEC-1)
DAM S.   Y VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
  MBJ UPDATE         04 JUN 79
**********

RUN  DATE 08/16/79
     TIME    09.54


                    NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
                    HYDROLOGIC AND HYDRAULIC ANALYSIS OF GRAHAMVILLE RES. MBJ  06
                    PROBABLE MAXIMUM FLOOD PMF/UNIT GRAPH BY SNYDERS METHOD

                                        JOB SPECIFICATION
                      NQ     NHR    NMIN    IDAY     IHR    IMIN   METRC   IPLT   IPRT   NSTAN
                     200       0      30       0       0       0       0      0      0       0
                                          JOPER     NWT   LROPT   TRACE
                                              5       0       0       0      0

                                  MULTI-PLAN ANALYSES TO BE PERFORMED
                                      NPLAN= 1 NRTIO= 1 LRTIO= 1
                            RTIOS=   0.50

**********      **********      **********      **********      **********

                                  SUB-AREA RUNOFF COMPUTATION

                          STORM HYDROGRAPH DEVELOPMENT BY SNYDERS UNIT HYDROGRAPH

                              ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                                  1       0       0       0       0       0       1       0       0

                                        HYDROGRAPH DATA
                      IHYDG    IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO  ISNOW  ISAME  LOCAL
                          1       1    1.64     0.0    1.64     0.0     0.0      0      0      0

                                          PRECIP DATA
                              SPFE     PMS      R6     R12     R24     R48     R72     R96
                               0.0   22.90  117.00  127.00  141.00  151.00     0.0     0.0
TRSPC COMPUTED BY THE PROGRAM IS 0.800

                                          LOSS DATA
                    LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
                        0     0.0     0.0    1.00     0.0     0.0    1.00    1.00    0.05     0.0     0.0

                                      UNIT HYDROGRAPH DATA
                                  TP=  1.52    CP=0.78    NTA=  0

                                        RECESSION DATA
                                STRTQ=   -1.50    QRCSN=   -0.05    RTIOR= 2.00
APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC= 4.29 AND R= 1.36 INTERVALS

                  UNIT HYDROGRAPH 10 END-OF-PERIOD ORDINATES. LAG=  1.51 HOURS. CP= 0.77  VOL= 1.00
                91.     298.     483.     522.     374.     187.      86.      40.      18.       8.

0                                   END-OF-PERIOD FLOW
```

Sheet 17 of 32

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	0.30	1	0.01	0.00	0.01	2.	1.03	2.30	101	0.0	0.0	0.0	158.
1.01	1.00	2	0.01	0.00	0.01	2.	1.03	3.00	102	0.0	0.0	0.0	147.
1.01	1.30	3	0.01	0.00	0.01	2.	1.03	3.30	103	0.0	0.0	0.0	137.
1.01	2.00	4	0.01	0.00	0.01	2.	1.03	4.00	104	0.0	0.0	0.0	128.
1.01	2.30	5	0.01	0.00	0.01	2.	1.03	4.30	105	0.0	0.0	0.0	120.
1.01	3.00	6	0.01	0.00	0.01	2.	1.03	5.00	106	0.0	0.0	0.0	112.
1.01	3.30	7	0.01	0.00	0.01	2.	1.03	5.30	107	0.0	0.0	0.0	104.
1.01	4.00	8	0.01	0.00	0.01	1.	1.03	6.00	108	0.0	0.0	0.0	97.
1.01	4.30	9	0.01	0.00	0.01	1.	1.03	6.30	109	0.0	0.0	0.0	91.
1.01	5.00	10	0.01	0.00	0.01	1.	1.03	7.00	110	0.0	0.0	0.0	85.
1.01	5.30	11	0.01	0.00	0.01	1.	1.03	7.30	111	0.0	0.0	0.0	79.
1.01	6.00	12	0.01	0.00	0.01	1.	1.03	8.00	112	0.0	0.0	0.0	74.
1.01	6.30	13	0.01	0.00	0.01	1.	1.03	8.30	113	0.0	0.0	0.0	69.
1.01	7.00	14	0.01	0.00	0.01	1.	1.03	9.00	114	0.0	0.0	0.0	64.
1.01	7.30	15	0.01	0.00	0.01	1.	1.03	9.30	115	0.0	0.0	0.0	60.
1.01	8.00	16	0.01	0.00	0.01	1.	1.03	10.00	116	0.0	0.0	0.0	56.
1.01	8.30	17	0.01	0.00	0.01	1.	1.03	10.30	117	0.0	0.0	0.0	52.
1.01	9.00	18	0.01	0.00	0.01	1.	1.03	11.00	118	0.0	0.0	0.0	49.
1.01	9.30	19	0.01	0.00	0.01	1.	1.03	11.30	119	0.0	0.0	0.0	45.
1.01	10.00	20	0.01	0.00	0.01	1.	1.03	12.00	120	0.0	0.0	0.0	42.
1.01	10.30	21	0.01	0.00	0.01	1.	1.03	12.30	121	0.0	0.0	0.0	39.
1.01	11.00	22	0.01	0.00	0.01	1.	1.03	13.00	122	0.0	0.0	0.0	37.
1.01	11.30	23	0.01	0.00	0.01	0.	1.03	13.30	123	0.0	0.0	0.0	34.
1.01	12.00	24	0.01	0.00	0.01	0.	1.03	14.00	124	0.0	0.0	0.0	32.
1.01	12.30	25	0.08	0.00	0.08	0.	1.03	14.30	125	0.0	0.0	0.0	30.
1.01	13.00	26	0.08	0.00	0.08	0.	1.03	15.00	126	0.0	0.0	0.0	28.
1.01	13.30	27	0.09	0.00	0.09	0.	1.03	15.30	127	0.0	0.0	0.0	26.
1.01	14.00	28	0.09	0.00	0.09	0.	1.03	16.00	128	0.0	0.0	0.0	24.
1.01	14.30	29	0.11	0.00	0.11	0.	1.03	16.30	129	0.0	0.0	0.0	23.
1.01	15.00	30	0.11	0.00	0.11	0.	1.03	17.00	130	0.0	0.0	0.0	21.
1.01	15.30	31	0.14	0.00	0.14	0.	1.03	17.30	131	0.0	0.0	0.0	20.
1.01	16.00	32	0.44	0.32	0.12	30.	1.03	18.00	132	0.0	0.0	0.0	18.
1.01	16.30	33	0.11	0.08	0.03	104.	1.03	18.30	133	0.0	0.0	0.0	17.
1.01	17.00	34	0.11	0.08	0.03	188.	1.03	19.00	134	0.0	0.0	0.0	16.
1.01	17.30	35	0.08	0.06	0.02	238.	1.03	19.30	135	0.0	0.0	0.0	15.
1.01	18.00	36	0.08	0.06	0.02	226.	1.03	20.00	136	0.0	0.0	0.0	14.
1.01	18.30	37	0.01	0.00	0.01	179.	1.03	20.30	137	0.0	0.0	0.0	13.
1.01	19.00	38	0.01	0.00	0.01	133.	1.03	21.00	138	0.0	0.0	0.0	12.
1.01	19.30	39	0.01	0.00	0.01	88.	1.03	21.30	139	0.0	0.0	0.0	11.
1.01	20.00	40	0.01	0.00	0.01	49.	1.03	22.00	140	0.0	0.0	0.0	11.
1.01	20.30	41	0.01	0.00	0.01	24.	1.03	22.30	141	0.0	0.0	0.0	10.
1.01	21.00	42	0.01	0.00	0.01	12.	1.03	23.00	142	0.0	0.0	0.0	9.
1.01	21.30	43	0.01	0.00	0.01	11.	1.03	23.30	143	0.0	0.0	0.0	9.
1.01	22.00	44	0.01	0.00	0.01	10.	1.04	0.0	144	0.0	0.0	0.0	8.
1.01	22.30	45	0.01	0.00	0.01	10.	1.04	0.30	145	0.0	0.0	0.0	7.
1.01	23.00	46	0.01	0.00	0.01	9.	1.04	1.00	146	0.0	0.0	0.0	7.
1.01	23.30	47	0.01	0.00	0.01	8.	1.04	1.30	147	0.0	0.0	0.0	7.
1.02	0.0	48	0.01	0.00	0.01	8.	1.04	2.00	148	0.0	0.0	0.0	6.
1.02	0.30	49	0.09	0.06	0.02	7.	1.04	2.30	149	0.0	0.0	0.0	6.
1.02	1.00	50	0.09	0.06	0.02	24.	1.04	3.00	150	0.0	0.0	0.0	5.
1.02	1.30	51	0.09	0.06	0.02	53.	1.04	3.30	151	0.0	0.0	0.0	5.
1.02	2.00	52	0.09	0.06	0.02	84.	1.04	4.00	152	0.0	0.0	0.0	5.
1.02	2.30	53	0.09	0.06	0.02	107.	1.04	4.30	153	0.0	0.0	0.0	4.
1.02	3.00	54	0.09	0.06	0.02	118.	1.04	5.00	154	0.0	0.0	0.0	4.
1.02	3.30	55	0.09	0.06	0.02	124.	1.04	5.30	155	0.0	0.0	0.0	4.
1.02	4.00	56	0.09	0.06	0.02	126.	1.04	6.00	156	0.0	0.0	0.0	3.
1.02	4.30	57	0.09	0.06	0.02	127.	1.04	6.30	157	0.0	0.0	0.0	3.
1.02	5.00	58	0.09	0.06	0.02	128.	1.04	7.00	158	0.0	0.0	0.0	3.
1.02	5.30	59	0.09	0.06	0.02	128.	1.04	7.30	159	0.0	0.0	0.0	3.
1.02	6.00	60	0.09	0.06	0.02	128.	1.04	8.00	160	0.0	0.0	0.0	3.
1.02	6.30	61	0.15	0.13	0.03	134.	1.04	8.30	161	0.0	0.0	0.0	2.
1.02	7.00	62	0.15	0.13	0.03	154.	1.04	9.00	162	0.0	0.0	0.0	2.
1.02	7.30	63	0.15	0.13	0.03	186.	1.04	9.30	163	0.0	0.0	0.0	2.
1.02	8.00	64	0.15	0.13	0.03	221.	1.04	10.00	164	0.0	0.0	0.0	2.

Sheet 10 of 32

1.02	8.30	65	0.13	0.13	0.03	240.	1.04	10.30	165	0.0	0.0	0.0	2.
1.02	9.00	66	0.15	0.13	0.03	259.	1.04	11.00	166	0.0	0.0	0.0	2.
1.02	9.30	67	0.15	0.13	0.03	265.	1.04	11.30	167	0.0	0.0	0.0	2.
1.02	10.00	68	0.15	0.13	0.03	267.	1.04	12.00	168	0.0	0.0	0.0	2.
1.02	10.30	69	0.15	0.13	0.03	269.	1.04	12.30	169	0.0	0.0	0.0	1.
1.02	11.00	70	0.15	0.13	0.03	269.	1.04	13.00	170	0.0	0.0	0.0	1.
1.02	11.30	71	0.15	0.13	0.03	269.	1.04	13.30	171	0.0	0.0	0.0	1.
1.02	12.00	72	0.15	0.13	0.03	269.	1.04	14.00	172	0.0	0.0	0.0	1.
1.02	12.30	73	1.07	1.05	0.03	352.	1.04	14.30	173	0.0	0.0	0.0	1.
1.02	13.00	74	1.07	1.05	0.03	626.	1.04	15.00	174	0.0	0.0	0.0	1.
1.02	13.30	75	1.29	1.26	0.03	1090.	1.04	15.30	175	0.0	0.0	0.0	1.
1.02	14.00	76	1.29	1.26	0.03	1634.	1.04	16.00	176	0.0	0.0	0.0	1.
1.02	14.30	77	1.61	1.58	0.03	2111.	1.04	16.30	177	0.0	0.0	0.0	1.
1.02	15.00	78	1.61	1.58	0.03	2490.	1.04	17.00	178	0.0	0.0	0.0	1.
1.02	15.30	79	1.95	1.93	0.03	2837.	1.04	17.30	179	0.0	0.0	0.0	1.
1.02	16.00	80	6.19	6.17	0.03	3568.	1.04	18.00	180	0.0	0.0	0.0	1.
1.02	16.30	81	1.50	1.48	0.03	4729.	1.04	18.30	181	0.0	0.0	0.0	1.
1.02	17.00	82	1.50	1.48	0.03	5637.	1.04	19.00	182	0.0	0.0	0.0	1.
1.02	17.30	83	1.18	1.15	0.03	5714.	1.04	19.30	183	0.0	0.0	0.0	1.
1.02	18.00	84	1.18	1.15	0.03	4834.	1.04	20.00	184	0.0	0.0	0.0	1.
1.02	18.30	85	0.13	0.10	0.03	3656.	1.04	20.30	185	0.0	0.0	0.0	0.
1.02	19.00	86	0.13	0.10	0.03	2680.	1.04	21.00	186	0.0	0.0	0.0	0.
1.02	19.30	87	0.13	0.10	0.03	1822.	1.04	21.30	187	0.0	0.0	0.0	0.
1.02	20.00	88	0.13	0.10	0.03	1107.	1.04	22.00	188	0.0	0.0	0.0	0.
1.02	20.30	89	0.13	0.10	0.03	636.	1.04	22.30	189	0.0	0.0	0.0	0.
1.02	21.00	90	0.13	0.10	0.03	387.	1.04	23.00	190	0.0	0.0	0.0	0.
1.02	21.30	91	0.13	0.10	0.03	290.	1.04	23.30	191	0.0	0.0	0.0	0.
1.02	22.00	92	0.13	0.10	0.03	269.	1.05	0.0	192	0.0	0.0	0.0	0.
1.02	22.30	93	0.13	0.10	0.03	251.	1.05	0.30	193	0.0	0.0	0.0	0.
1.02	23.00	94	0.13	0.10	0.03	234.	1.05	1.00	194	0.0	0.0	0.0	0.
1.02	23.30	95	0.13	0.10	0.03	218.	1.05	1.30	195	0.0	0.0	0.0	0.
1.03	0.0	96	0.13	0.10	0.03	210.	1.05	2.00	196	0.0	0.0	0.0	0.
1.03	0.30	97	0.0	0.0	0.0	208.	1.05	2.30	197	0.0	0.0	0.0	0.
1.03	1.00	98	0.0	0.0	0.0	194.	1.05	3.00	198	0.0	0.0	0.0	0.
1.03	1.30	99	0.0	0.0	0.0	181.	1.05	3.30	199	0.0	0.0	0.0	0.
1.03	2.00	100	0.0	0.0	0.0	169.	1.05	4.00	200	0.0	0.0	0.0	0.

SUM	27.66	25.23	2.43
	(703.)(	641.)(	62.)(

55813.
1580.45)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	5714.	3454.	1084.	387.	55812.
CMS	162.	98.	31.	11.	1580.
INCHES		19.59	24.59	26.36	26.38
MM		497.61	624.66	669.60	670.08
AC-FT		1713.	2150.	2305.	2306.
THOUS CU M		2113.	2652.	2843.	2845.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 1

1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	15.	52.	94.	119.	113.	90.	66.	44.	25.
12.	6.	5.	5.	5.	4.	4.	4.	4.	12.
26.	62.	54.	59.	62.	63.	64.	64.	64.	64.
67.	77.	93.	111.	123.	129.	132.	134.	134.	135.
135.	135.	176.	313.	545.	817.	1055.	1245.	1418.	1784.
2365.	2818.	2857.	2417.	1828.	1340.	911.	553.	318.	193.
145.	134.	125.	117.	109.	109.	104.	97.	91.	85.
79.	74.	69.	64.	60.	56.	52.	49.	45.	42.
39.	37.	34.	32.	30.	28.	26.	24.	23.	21.
20.	18.	17.	16.	15.	14.	13.	12.	11.	11.
10.	9.	9.	8.	7.	7.	7.	6.	6.	5.
5.	5.	4.	4.	4.	3.	3.	3.	3.	3.

Sheet 19 of 32

2.	2.	2.	2.	2.	2.	2.	2.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	2857.	1727.	542.	194.	27906.
CMS	81.	49.	15.	5.	790.
INCHES		9.80	12.30	13.16	13.19
MM		248.81	312.33	334.80	335.04
AC-FT		856.	1075.	1152.	1153.
THOUS CU M		1056.	1326.	1421.	1422.

********** ********** ********** ********** **********

Sheet 20 of 32

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

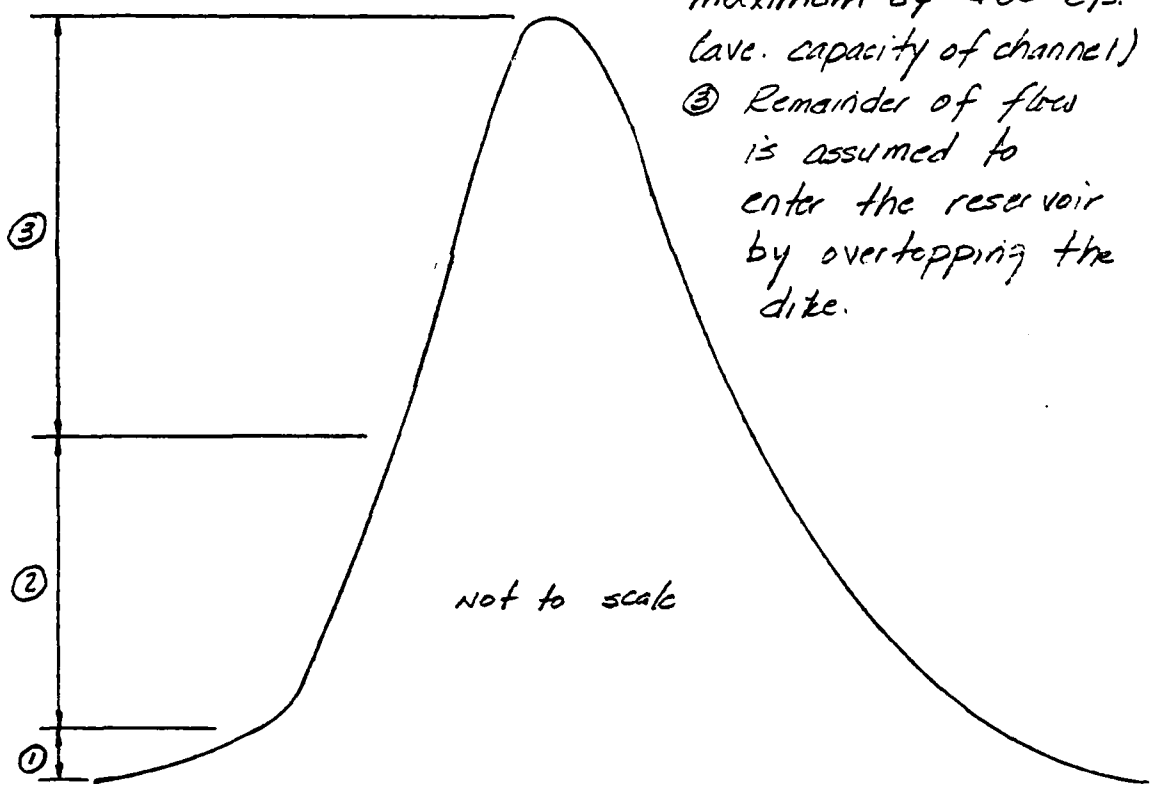
Subject Grahamville Dam S.O. No.
Hydrograph Development Sheet No. 21 of 32
Drawing No.
Computed by REH Checked by Date 8/17/79

The storm hydrographs were adjusted to account for discharges entering the inlet pipes and discharges diverted around the reservoir through the diversion channel.

① Flow through 2-18" inlet pipes up to a maximum of 32 cfs.

② Flow diverted by diversion channel to a maximum of 485 cfs. (ave. capacity of channel)

③ Remainder of flow is assumed to enter the reservoir by overtopping the dike.



```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
    MBJ UPDATE       04 JUN 79
**********
    1          A1    NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
    2          A2    HYDROLOGIC AND HYDRAULIC ANALYSIS OF GRAHAMVILLE RES. MBJ  06
    3          A3  .450 PROBABLE MAXIMUM FLOOD PMF/UNIT GRAPH BY SNYDERS METHOD
    4          B   130       0      30       0       0       0       0       0      -4       0
    5          B1    5
    6          J     1       1       1
    7          J1  1.0
    8          K     0       1                                       1
    9          K1      STORM HYDROGRAPH DEVELOPMENT BY SNYDERS UNIT HYDROGRAPH
   10          M    -1            1.64
   11          N     0       8      26      32      32      32      32      32      22      12
   12          N     6       3       2       2       2       2       2       2       2       0
   13          N    13      21      27      30      31      32      32      32      32      32
   14          N    32      32      32      32      32      32      32      32      32      32
   15          N    32      32      32      32      60     332     570     760     933    1299
   16          N  1880    2333    2372    1932    1343     855     426      98      32      32
   17          N    32      32      32      32      32      32      32      32      32      32
   18          N    32      32      32      32      30      28      26      25      22      21
   19          N    20      18      17      16      15      14      13      12      11      10
   20          N    10       9       8       8       7       7       6       6       5       5
   21          N     5       5       5       4       4       4       4       3       3       3
   22          N     2       2       2       2       2       2       2       2       2       2
   23          N     1       1       1       1       1       1       1       1       1       0
   24          K     1       2                                       1
   25          K1      FLOOD ROUTING FOR GRAHAMVILLE DAM
   26          Y                                   1       1
   27          Y1    1                                           -1237.3      -1
   28          Y41237.3  1239.2  1240.7  1242.2  1243.7  1245.2
   29          Y5    0       9      64     156     287     457
   30          $5  140     200     216
   31          $E1237.3  1242.6  1244
   32          $$1237.3
   33          $D1243.1    2.65     1.5     400
   34          K    99
```

Sheet 22 of 32

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
  MAJ UPDATE         04 JUN 79
**********

RUN  DATE 08/17/79
     TIME    11.03
```

NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
HYDROLOGIC AND HYDRAULIC ANALYSIS OF GRAHAMVILLE RES. MBJ 06
PROBABLE MAXIMUM FLOOD PMF/UNIT GRAPH BY SNYDERS METHOD

JOB SPECIFICATION

NO	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
130	0	30	0	0	0	0	0	79	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 1 LRTIO= 1

RTIOS= 1.00

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

STORM HYDROGRAPH DEVELOPMENT BY SNYDERS UNIT HYDROGRAPH

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
-1	0	1.64	0.0	1.64	0.0	0.0	0	0	0

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

FLOOD ROUTING FOR GRAHAMVILLE DAM

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.0	0.0	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.0	0.0	0.0	-1237.	-1

STAGE	1237.30	1239.20	1240.70	1242.20	1243.70	1245.20

Sheet 23 of 32

FLOW	0.0	9.00	64.00	156.00	267.00	457.00
CAPACITY=	140.	200.	216.			
ELEVATION=	1237.	1243.	1244.			

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
1237.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
1243.1	2.6	1.2	400.

PEAK OUTFLOW IS 2400. AT TIME 26.50 HOURS

********** ********** ********** ********** **********

Sheet 24 of 32

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 1.00
HYDROGRAPH AT	1	1.64 (4.25)	1	2372. (67.17)
ROUTED TO	2	1.64 (4.25)	1	2400. (67.96)

Sheet 25 of 32

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1

	INITIAL VALUE	SPILLWAY CREST	AVERAGE TOP OF DAM
ELEVATION	1237.30	1237.30	1243.10
STORAGE	140.	140.	206.
OUTFLOW	0.	0.	235.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
~~1.00~~ 0.50	1244.63	1.53	223.	2400.	5.00	26.50	0.0

Sheet 26 of 32

```
**********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
  MBJ UPDATE         04 JUN 79
**********************************
     1          A1       NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
     2          A2       HYDROLOGIC AND HYDRAULIC ANALYSIS OF GRAHAMVILLE DAM, MBJ  06
     3          A3  .425 PROBABLE MAXIMUM FLOOD PMF/UNIT GRAPH BY SNYDERS METHOD
     4          B    130       0      30       0       0       0       0       0      -4       0
     5          B1     5
     6          J      1       1       1
     7          J1   1.0
     8          K      0       1                                                       1
     9          K1       STORM HYDROGRAPH DEVELOPMENT BY SNYDERS UNIT HYDROGRAPH
    10          N     -1                1.64
    11          N      0       3      13      24      30      29      22      16      11       6
    12          N      3       2       2       2       1       1       1       1       1       3
    13          N      7      10      13      15      15      16      16      16      16      16
    14          N     17      20      23      28      31      32      32      32      32      32
    15          N     32      32      32      32      32      32      43     137     224     407
    16          N    697     924     943     723     429     185      32      32      32      32
    17          N     32      32      31      29      27      27      26      24      23      21
    18          N     20      18      17      16      15      14      13      12      11      10
    19          N     10       9       8       8       7       7       6       6       6       5
    20          N      5       5       5       4       4       3       3       3       3       2
    21          N      2       2       2       2       2       2       2       2       2       2
    22          N      1       1       1       1       1       1       1       1       1       1
    23          N      1       0       0       0       0       0       0       0       0       0
    24          K      1       2                                                       1
    25          K1       FLOOD ROUTING FOR GRAHAMVILLE DAM
    26          Y                                       1       1
    27          Y1     1                                                -1237.3      -1
    28          Y41237.3  1239.2  1240.7  1242.2  1243.7  1245.2
    29          Y5     0       9      64     156     287     457
    30          $S   140     200     216
    31          $$1237.3  1242.6  1244
    32          $$1237.3
    33          $D1243.1    2.65     1.5     400
    34          K     90
```

Sheet 27 of 32

****
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM V - 81X VERSION JULY 1978
LAST MODIFICATION 26 FEB 79
MBJ UPDATE 04 JUN 79
****

RUN DATE 33/11/79
TIME 13.19

NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS
HYDROLOGIC AND HYDRAULIC ANALYSIS OF GRAHAMVILLE RES. MBJ 06
PROBABLE MAXIMUM FLOOD PMF/UNIT GRAPH BY SNYDERS METHOD

JOB SPECIFICATION

IO	NRP	DMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
30	0	30	0	0	0	0	0	-4	0
			JOPER	NWT	IOPT	TRACE			
			5	0	0	0	0		

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 1 LRTIO= 1

RTIOS= 1.00

****

SUB-AREA RUNOFF COMPUTATION

STORM HYDROGRAPH DEVELOPMENT BY SNYDERS UNIT HYDROGRAPH

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
-1	0	1.64	0.0	1.64	0.0	0.0	0	0	0

****

HYDROGRAPH ROUTING

FLOOD ROUTING FOR GRAHAMVILLE DAM

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	1	0	0	0	0	1	0	0

ROUTING DATA

JLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.0	0.0	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.0	0.0	0.0	-1237.	-1

STAGE	1237.30	1239.20	1240.70	1242.20	1243.70	1245.20
FLOW	0.0	9.00	64.00	156.00	287.00	457.00

Sheet 18 of 32

CAPACITY= 140. 200. 216.

ELEVATION= 1237. 1243. 1244.

CREL	SPWID	COQW	EXPW	ELEVL	COOL	CAREA	EXPL
1237.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
1243.1	2.6	1.5	400.

PEAK OUTFLOW IS 983. AT TIME 26.50 HOURS

********** ********** ********** ********** **********

Sheet 29 of 32

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1
				1.00
HYDROGRAPH AT	1	1.64	1	943.
		(4.25)		(26.70)
ROUTED TO	2	1.64	1	983.
		(4.25)		(27.84)

Sheet 30 of 32

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	AVERAGE TOP OF DAM
ELEVATION	1237.30	1237.30	1243.10
STORAGE	140.	140.	206.
OUTFLOW	0.	0.	235.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
~~1.00~~ 0.25	1243.84	0.74	214.	983.	2.50	26.50	0.0

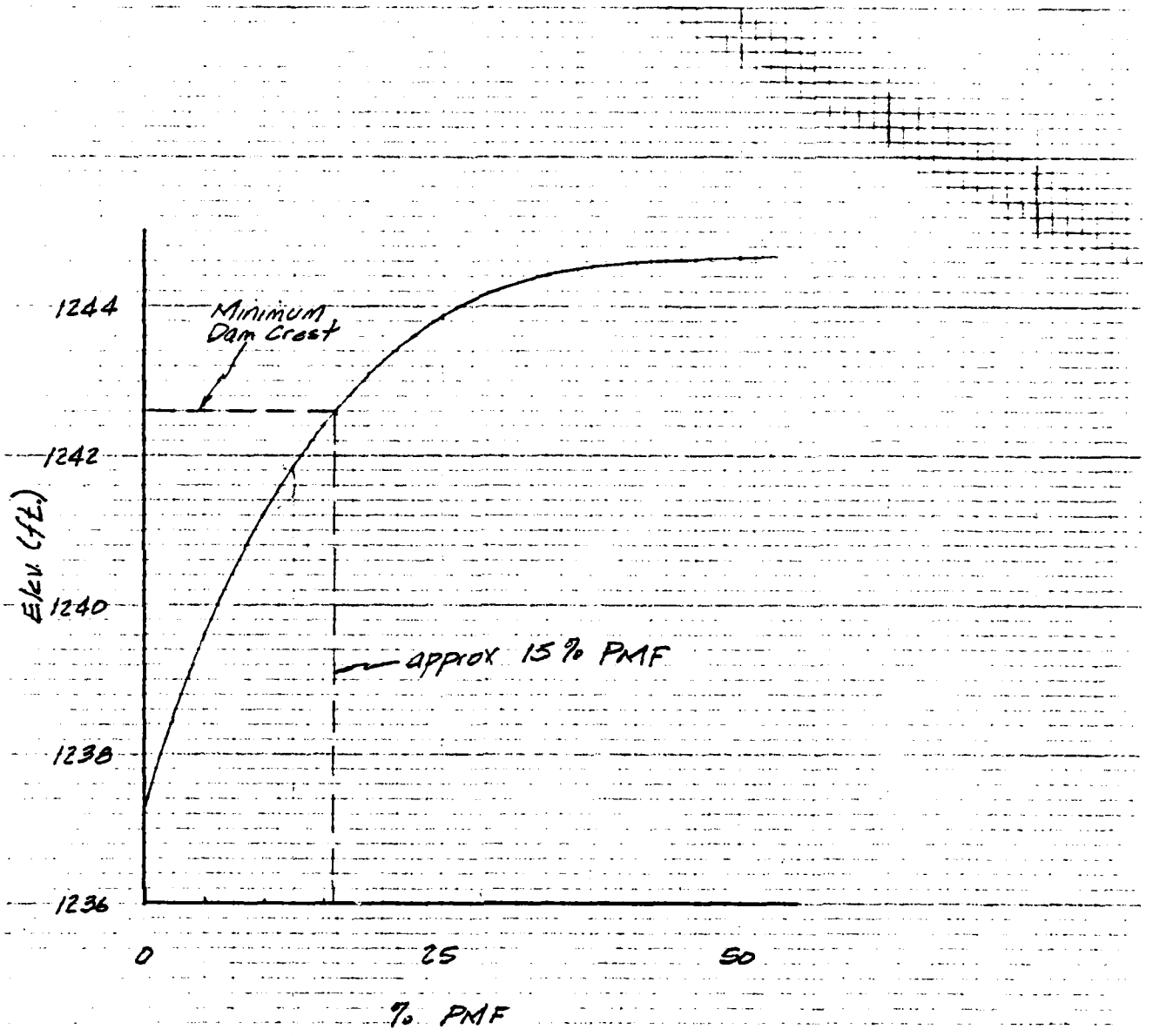
Sheet 31 of 32

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject Grahamville Dam
Overtopping Potential

S.O. No.
Sheet No. 32 of 32
Drawing No.
Computed by REH Checked by Date 8-16-79



APPENDIX E

REGIONAL GEOLOGY

GRAHAMVILLE RESERVOIR DAM
NDI No. PA 00020, PennDER 25-2

GENERAL GEOLOGY

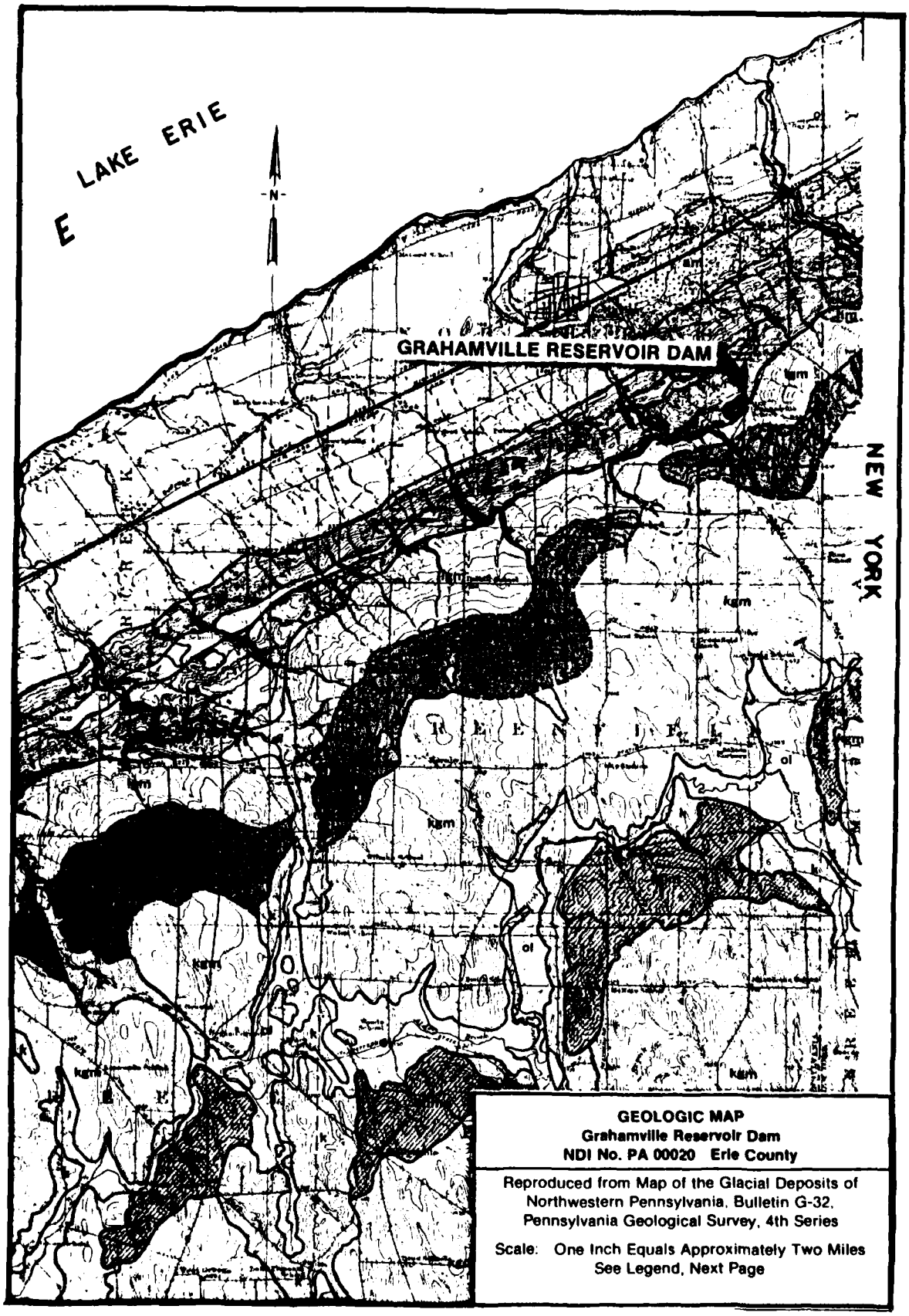
Grahamville Reservoir is located in the glaciated section of the Appalachian Plateaus physiographic province, approximately 4 miles southeast of Lake Erie. The normal pool of the reservoir is approximately 665 feet above mean lake level.

No design information is available describing geologic and soil conditions at the dam site. However, a 1916 inspection report of the Water Supply Commission of Pennsylvania describes the site geology as layers of sand and clay of variable depth overlying a gray slate formation. [The term "slate" is frequently misused as a synonym for shale.]

According to the geologic map on the following page, bedrock units in the general area of the dam and reservoir are members of the Conneaut group, Devonian system. These units are described on the accompanying legend as typically being shales and siltstones.

Although little specific data are available relative to the thickness and gradation of glacial till beneath the dam, some insight into its character can be obtained from the descriptions given for materials penetrated by a nearby water well. According to the well log, the area is mantled by glacial gravels approximately 19 feet thick. This information, however, can only be considered indicative of general conditions since high variability of materials can be expected.

The geologic map and legend are given on the following pages.

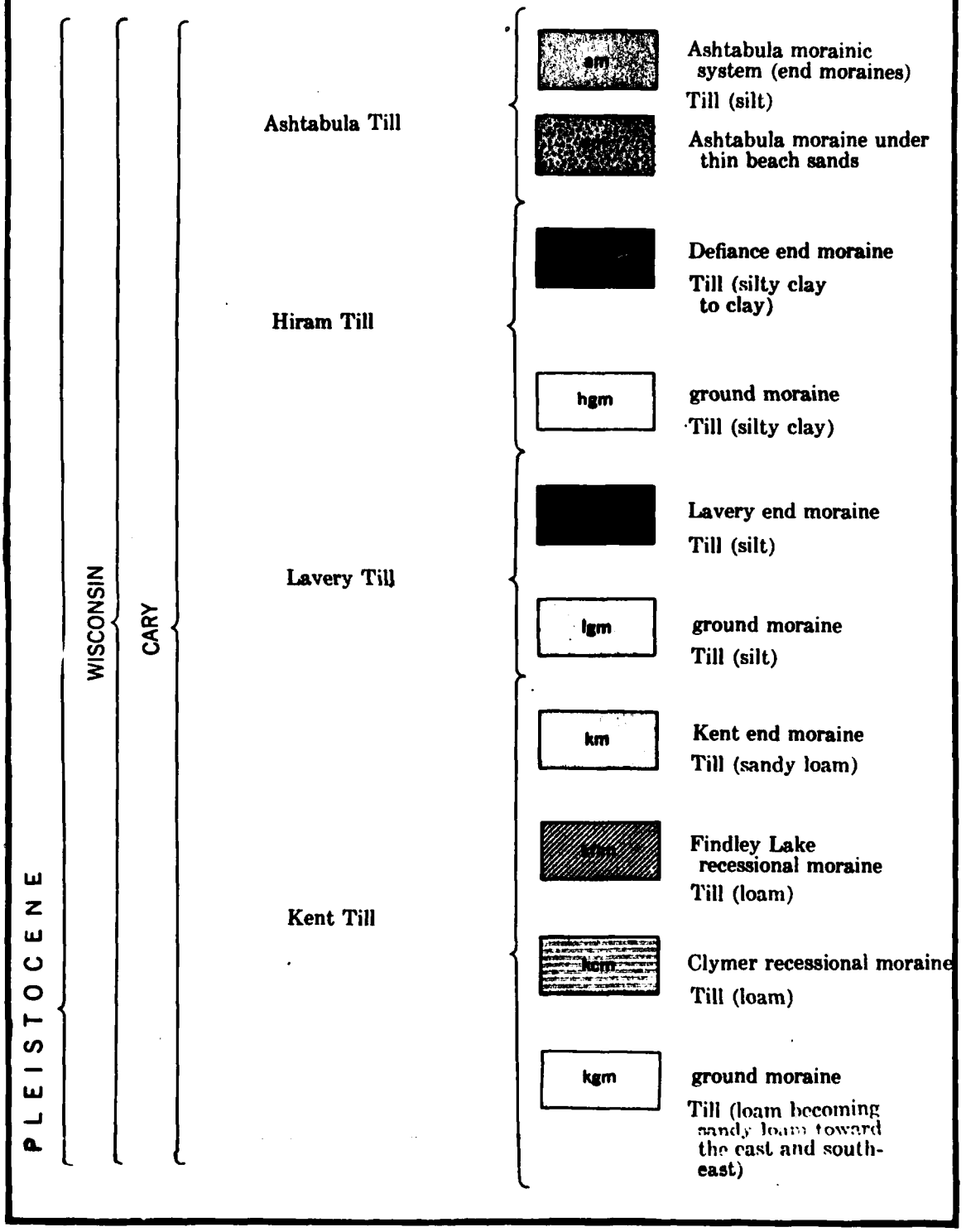


GEOLOGIC MAP
Grahamville Reservoir Dam
NDI No. PA 00020 Erie County

Reproduced from Map of the Glacial Deposits of Northwestern Pennsylvania, Bulletin G-32, Pennsylvania Geological Survey, 4th Series

Scale: One Inch Equals Approximately Two Miles
See Legend, Next Page

LEGEND


PLEISTOCENE
WISCONSIN
CARY
Ashtabula Till
Hiram Till
Lavery Till
Kent Till
am
Ashtabula morainic system (end moraines)
Till (silt)
Ashtabula moraine under thin beach sands
Defiance end moraine
Till (silty clay to clay)
hgm
ground moraine
Till (silty clay)
Lavery end moraine
Till (silt)
lgm
ground moraine
Till (silt)
km
Kent end moraine
Till (sandy loam)
Findley Lake recessional moraine
Till (loam)
Clymer recessional moraine
Till (loam)
kgm
ground moraine
Till (loam becoming sandy loam toward the east and southeast)